8327376

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

December 20, 2022

THIS IS TO CERTIFY THAT ANNEXED IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF THE FILE WRAPPER AND CONTENTS OF:

APPLICATION NUMBER: *15/600,054*
FILING DATE: *May 19, 2017*
PATENT NUMBER: *10528036*
ISSUE DATE: *January 07, 2020*

Certified by

Performing the Functions and Duties of the
Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

PTO/AIA/15 (03-13)
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	RYZ01 P-101B
First Named Inventor	Paul Ryznar
Title	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☐ **Fee Transmittal Form** (PTO/SB/17 or equivalent)
2. ☑ **Applicant asserts small entity status.** See 37 CFR 1.27
3. ☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
4. ☑ **Specification** [*Total Pages* 34] Both the claims and abstract must start on a new page. *(See MPEP § 608.01(a) for information on the preferred arrangement)*
5. ☑ **Drawing(s)** (35 U.S.C. 113) [*Total Sheets* 14]
6. **Inventor's Oath or Declaration** [*Total Pages* 1] *(including substitute statements under 37 CFR 1.64 and assignments serving as an oath or declaration under 37 CFR 1.63(e))*
   a. ☐ Newly executed (original or copy)
   b. ☑ A copy from a prior application (37 CFR 1.63(d))
7. ☑ **Application Data Sheet** ** See note below.* See 37 CFR 1.76 (PTO/AIA/14 or equivalent)
8. **CD-ROM or CD-R** in duplicate, large table, or Computer Program (*Appendix*)
   ☐ Landscape Table on CD
9. **Nucleotide and/or Amino Acid Sequence Submission** (*if applicable, items a. – c. are required*)
   a. ☐ Computer Readable Form (CRF)
   b. ☐ Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ Paper
   c. ☐ Statements verifying identity of above copies

ADDRESS TO:

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

ACCOMPANYING APPLICATION PAPERS

10. ☐ **Assignment Papers** (cover sheet & document(s))
    Name of Assignee _____
11. ☐ **37 CFR 3.73(c) Statement** (*when there is an assignee*) ☐ **Power of Attorney**
12. ☐ **English Translation Document** (*if applicable*)
13. ☑ **Information Disclosure Statement** (PTO/SB/08 or PTO-1449)
    ☐ Copies of citations attached
14. ☐ **Preliminary Amendment**
15. ☐ **Return Receipt Postcard** (*MPEP § 503*) (*Should be specifically itemized*)
16. ☐ **Certified Copy of Priority Document(s)** (*if foreign priority is claimed*)
17. ☐ **Nonpublication Request** Under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
18. ☐ **Other:** _____

Note*: (1) Benefit claims under 37 CFR 1.78 and foreign priority claims under 1.55 **must be included in an Application Data Sheet (ADS).
(2) For applications filed under 35 U.S.C. 111, the application must contain an ADS specifying the applicant if the applicant is an assignee, person to whom the inventor is under an obligation to assign, or person who otherwise shows sufficient proprietary interest in the matter. See 37 CFR 1.46(b).

19. CORRESPONDENCE ADDRESS

☑ The address associated with Customer Number: 15671 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	/Karl T. Ondersma/	Date	May 19, 2017
Name (Print/Type)	Karl T. Ondersma	Registration No. (Attorney/Agent)	55894

This collection of information is required by 37 CFR 1.53(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors : Paul Ryznar and James Ryznar
For : LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Dear Sir:

REQUEST FOR FILING CONTINUATION APPLICATION
UNDER 37 CFR 1.53(b)

This is a request for filing a continuation application under 37 CFR 1.53 of co-pending application Serial No. 13/984,744, filed August 9, 2013, by Paul Ryznar and James Ryznar, entitled LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD, which is a U.S. national stage application and claims the benefit of International Patent Application No. PCT/US2012/024730, filed February 10, 2012, which claims priority of U.S. provisional patent app. Ser. No. 61/441,897 filed February 11, 2011.

1. Attached Application

I hereby verify that the attached papers are a copy of what is shown in my records to be the above-identified prior application Serial No. 13/984,744, but with an updated Cross Reference to Related Applications and new claims 1-3 being presented in the present continuation application filing. The attached application includes 31 pages of specification, 2 pages of claims, 1 page of Abstract, and 14 sheets of drawings.

2. Patent Application Bibliographic Data Form

A copy of the Patent Application Bibliographic Data Form is attached.

3. Disclosure Statement

Applicants respectfully request that information cited in the prior parent application, Serial No. 13/984,744, be considered in the present application. An Information Disclosure Statement is included herewith that lists the cited references.

4. Assignment

The prior application was originally assigned to OPS Solutions LLC, a corporation of the State of Michigan. That Assignment was recorded in the United States Patent and Trademark Office on August 9, 2013, at Reel 030980, Frame 0629.

5. Inventorship Statement

With respect to the prior co-pending U.S. application from which this application claims benefit under 35 U.S.C. 120, the inventors in this application is the same, namely, Paul Ryznar and James Ryznar.

6. Correspondence Address

Please address all future correspondence to:

Karl T. Ondersma
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Drive, S.E., Ste. 207
Grand Rapids, MI 49546
Ph: (616) 988-4123
Fax: (616) 975-5505

67 Verification

I hereby declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Respectfully submitted,

/Karl T. Ondersma/

Date: May 19, 2017

Karl T. Ondersma
Registration No. 55894
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Drive, S.E., Ste. 207
Grand Rapids, MI 49546
(616) 975-5500

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	RYZ01 P-101B
	Application Number	
Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Paul		Ryznar	

Residence Information (Select One) ● US Residency Non US Residency Active US Military Service

City	State/Province	Country of Residence
Northville	MI	US

Mailing Address of Inventor:

Address 1	49601 Deer Run Drive
Address 2	
City	Northville
State/Province	MI
Postal Code	48167
Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	James		Ryznar	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

City	State/Province	Country of Residence
Belleville	MI	US

Mailing Address of Inventor:

Address 1	11535 Ryznar Drive
Address 2	
City	Belleville
State/Province	MI
Postal Code	48111
Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	RYZ01 P-101B
	Application Number	
Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	15671		
Email Address	ondersma@glbf.com	Add Email	Remove Email

Application Information:

Title of the Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD		
Attorney Docket Number	RYZ01 P-101B	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	14	**Suggested Figure for Publication (if any)**	1

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	15671		

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	RYZ01 P-101B
	Application Number	
Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	13984744	2013-08-09
Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
13984744	a 371 of international	PCT/US2012/024730	2012-02-10
Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
PCT/US2012/024730	Claims benefit of provisional	61441897	2011-02-11

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	RYZ01 P-101B
	Application Number	
Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	RYZ01 P-101B
	Application Number	
Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	RYZ01 P-101B
	Application Number	
Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	OPS Solutions LLC		
Mailing Address Information For Applicant:			
Address 1	48443 Alpha Dr.		
Address 2	Suite 175		
City	Wixom	**State/Province**	MI
Country	US	Postal Code	48393
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

PTO/AIA/14 (11-15)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	RYZ01 P-101B
	Application Number	
Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Karl T. Ondersma/			Date (YYYY-MM-DD)	2017-05-19
First Name	Karl T.	Last Name	Ondersma	Registration Number	55894

Additional Signature may be generated within this form by selecting the Add button. Add

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	RYZ01 P-101B
	Application Number	
Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application is a continuation of U.S. application Serial No. 13/984,744, filed August 9, 2013, which is a U.S. national stage application and claims the benefit of International Patent App. PCT/US2012/024730, filed February 10, 2012, which claims priority of U.S. provisional application, Ser. No. 61/441,897 filed February 11, 2011, by Paul Ryznar and James Ryznar for LIGHT GUIDED ASSEMBLY SYSTEM, which are hereby incorporated herein by reference in their entireties.

BACKGROUND OF THE INVENTION

[0002] The present invention is directed to improvements in a system for guiding an individual in the performance of operational steps, and in particular a system that provides visual indicators to the individual.

[0003] U.S. Patent No. 7,515,981 provides a LIGHT GUIDED ASSEMBLY SYSTEM for aiding human actions. Numerous activities involve the performance of pre-designated operational steps to properly complete a particular task, with some such activities needing to be completed within a specified or standard time allowance. Problems arise when such activities are improperly performed either from a workmanship standpoint and/or outside the standard time allowance, both of which add significant and undesirable cost and complexity to the manufacturing operations. In the case of failure to meet a standard time allowance, an entire assembly process may become unbalanced resulting in costly bottlenecks and excess inventory.

[0004] In addition to manufacturing assembly operations, numerous other activities involve human performance of particular tasks that are desired to be performed without omitting any steps.

SUMMARY OF THE INVENTION

[0005] The present invention provides a guide system adapted to provide visual indicators to an individual to guide actions.

[0006] According to an aspect of the present invention, a method of projecting visual indicators onto a physical object to guide actions of an individual comprises providing a guide system having a guide system controller and a projector, with the guide system controller including a plurality of addressed display features. The method further comprises providing an input signal to the guide system controller, selecting an addressed display feature based on

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the input signal, and projecting a visual indicator corresponding to the selected addressed display feature onto a physical object. The guide system controller may further include a plurality of positional identifiers with the method further comprising selecting a positional identifier based on the input signal, and projecting a visual indicator corresponding to the selected addressed display feature onto a physical object at a location corresponding to the selected positional identifier.

[0007] The guide system controller may be interfaced with a manufacturing execution system (MES), wherein the input signal is provided to the guide system controller from the manufacturing execution system. Alternatively or additionally, the guide system controller may be interfaced with a system controller that controls the operation of an automated process, wherein the input signal is provided to the guide system controller from the system controller. The system controller may be a programmable logic controller and receive signals from a sensor apparatus, wherein the input signal is provided to the guide system controller based on signals received by the system controller from the sensor apparatus. The system controller may be interfaced with a manufacturing execution system. Either the manufacturing execution system and/or the system controller may receive signals from a sensor apparatus, or receive manually input signals, with such signals comprising or deriving an input signal to the guide system controller prompting the projection of a visual indicator.

[0008] The method may further comprise the providing of a confirmation signal to the guide system controller in response to completion of an action by an individual based on the visual indicator. A sensor apparatus may be provided that is operable to detect completion of the action, with the sensor apparatus generating a confirmation signal.

[0009] The guide system may further include a camera operable to image at least one of actions of an individual guided by the visual indicator and the visual indicator, with the method further including recording images while an operator is guided by the guide system and/or recording the time duration while an operator is guided by the guide system. Simultaneously recorded images and recorded time durations may be displayed, such as on a monitor, for evaluating process improvements.

[0010] A guide system for providing visual indicators to an individual to guide actions in accordance with an aspect of the invention comprises at least one directional light device selectively operable to project and target at least one indicating light, a guide system controller including a plurality of programmed addressed display features and a plurality of

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programmed positional identifiers. The guide system controller receives an input signal and causes the directional light device to project a visual indicator corresponding to an addressed display feature onto a physical object at a location corresponding to a positional identifier based on the input signal.

[0011] The guide system controller may be interfaced with a manufacturing execution system to provide the input signal to the guide system controller, or may be interfaced with a system controller that controls the operation of an automated process to provide the input signal to the guide system. Both the manufacturing execution system and a system controller, such as a programmable logic controller, may receive signals from a sensor apparatus, wherein the input signal is provided to the guide system controller based on the signals received by the manufacturing execution system and/or the system controller from the sensor apparatus. The system controller may be interfaced with a manufacturing execution system.

[0012] A camera operable to image the actions of an individual guided by a visual indicator or a visual indicator itself may be included in the guide system where a controller, such as the guide system controller, records images and time durations while an operator is guided. A monitor interfaced with the guide system controller may be used to view recorded images and time durations.

[0013] Still further, a guide system adapted to provide visual indicators to an individual to guide actions in accordance with the present invention comprises a guide system controller, a projector selectively operable to project and target a visual indicator, and a camera operable to image at least one of actions of an individual guided by the visual indicator or the visual indicator. The guide system controller receives an input signal and causes the projector to project a visual indicator onto a physical object based on the input signal with the guide system controller recording images and time durations while an individual is guided by the visual indicator, which recorded images and time durations may be viewable on a monitor. The guide system controller may include a plurality of programmed addressed display features and a plurality of programmed positional identifiers, wherein the guide system controller causes the projector to project the visual indicator corresponding to an addressed display feature onto a physical object at a location corresponding to a positional identifier based on the input signal.

[0014] A motion sensor may be incorporated with any of the guide systems, with the motion sensor detecting three dimensional spatial motion of an individual, a product, or a workstation

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process guided by a visual indicator. The motion sensor may output a confirmation signal when the three dimensional spatial motion detected by the motion sensor complies with a desired action, where the confirmation signal may be transmitted to the guide system controller and/or other controllers.

[0015] According to another aspect of the invention, a guide system adapted to provide visual indicators to an individual to guide sequential actions comprises an operational guide system interfaced with an operational software system or manufacturing execution system, with the operational guide system comprising at least one directional light device selectively operable to project and target at least one indicating light and a controller, with the controller receiving input signals and selectively providing command signals to the directional light device in response to the input signals wherein the projection of the indicating light is indicative of the command signal. The operational software system being operable to provide data inputs to the operational guide system that comprise input signals to the controller. The controller may be programmed with a plurality of addressed display features and a plurality of programmed positional identifiers, where the controller receives an input signal and causes the directional light device to project a visual indicator corresponding to an addressed display feature onto a physical object at a location corresponding to a positional identifier based on the input signal.

[0016] The indicating light may create a human readable display image based on the data inputs, and may comprise numbers, words, alphanumeric characters, a drawing image and/or a video image. The data inputs may alternatively or additionally direct the projection location of the indicating lights. The operational guide system may further include a sensor apparatus that is operable to detect operation information and generate an output indicative of the operation information. Conditional programming can also be employed to redirect an operator to a different set of process steps dependent on the outcome of prior steps as determined by the operator, controller, confirmation devices, and/or computer MES system or the like.

[0017] According to another aspect of the invention, an operational guide system adapted to provide visual indicators to an individual to guide sequential actions comprises at least one directional light device, a guide system controller, and a camera. The directional guide light device being selectively operable to project and target at least one indicating light for guiding actions of an individual and the guide system controller receiving an input signal and selectively providing a command signal to the directional light device in response to the input signal, wherein the projection of the indicating light is indicative of the command signal. The

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camera is operable to image the actions of an individual guided by the operational guide system and/or the impingement of the indicating light on an object. Images recorded by the camera can be viewed in combination with recorded cycle time data to review the recorded process steps and determine corrective actions to optimize the process and/or reduce cycle times.

[0018] In particular embodiments the camera may be a video camera. A monitor may be interfaced with the guide system controller such that images take by the camera are viewable on the monitor. A light controller may be interfaced with the guide system controller for providing input signals to the guide system controller for operatively controlling the projection of the indicating light. A camera controller may also be interfaced with the guide system controller, with the camera controller being operable to control the zoom, viewing position, and/or focus of the camera. Still further, a computer may be interfaced with the guide system controller, such as a distally located computer, with the images taken by the camera being viewable on a monitor of the computer. The computer may also be operable to provide input signals to the guide system controller for operatively controlling the projection of the indicating light and/or the zoom, viewing position, and/or focus of the camera.

[0019] According to yet another aspect of the invention, an operational guide system adapted to provide visual indicators to an individual to guide sequential actions includes a projection surface having a front surface and a rear surface opposite the front surface. A directional light device selectively projects and targets at least one indicating light on the rear surface of the projection surface to create display images on the projection surface, wherein the display images are viewable by an individual viewing the front surface of the projection surface to guide actions of the individual.

[0020] According to another aspect of the invention, an operational guide system adapted to provide visual indicators to an individual to guide sequential actions comprises at least one directional light device, a guide system controller, and a motion sensor. The directional guide light device being selectively operable to project and target at least one indicating light for guiding actions of an individual and the guide system controller receiving an input signal and selectively providing a command signal to the directional light device in response to the input signal, wherein the projection of the indicating light is indicative of the command signal. The motion sensor detects three dimensional spatial motion, such as of the individual, product, or workstation process being guided by the indicating light.

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[0021] In particular embodiments, the three dimensional spatial motion of the individual detected by the motion sensor comprises a confirmation signal when the detected motion complies with a desired action. For example, the three dimensional spatial motion of the individual detected by the motion sensor may be transmitted to the guide system controller for comparison with the desired action.

[0022] The operational guide system of the present invention is thus readily programmable and adaptable to provide a cost effective and accurate method of guiding an individual through a series of tasks and may also provide confirmation that the tasks have been fully completed in the proper order, as well as additional information regarding cycle times and images recorded during operations.

[0023] These and other objects, advantages, purposes, and features of this invention will become apparent upon review of the following specification in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. 1 is a perspective view of an operational guide system constructed as an assembly guide system at a work station of an assembly line;

[0025] FIGS. 1A-1L illustrate exemplary images that may be projected by the light sources of the assembly guide system of FIG. 1;

[0026] FIG. 2 is a schematic illustration of the operation of the assembly guide system of FIG. 1;

[0027] FIG. 3 is a schematic illustration of an alternative operational guide system in accordance with the present invention interfaced with a manufacturing execution system;

[0028] FIG. 3A is a schematic illustration of a guide system controller of the guide system of FIG. 3 including a programmed addressed visual display features and a matrix of positional identifiers;

[0029] FIG. 3B is a schematic illustration of projectors of the guide system of FIG. 3 projecting visual indicators onto objects corresponding to the addressed visual display features and positional identifiers of FIG. 3A;

[0030] FIG. 3C is a schematic illustration of the interfacing of the manufacturing execution system and guide system of FIG. 3;

[0031] FIG. 3D is a schematic illustration of a guide system interfaced with a system controller of an automated process, and of a manufacturing execution system interfaced with the system controller;

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[0032] FIG. 3E schematically illustrates various alternatives by which a guide system controller may receive input signals and confirmation signals;

[0033] FIG. 4 is a schematic illustration of an alternative operational guide system in accordance with the present invention incorporating a camera device;

[0034] FIGS. 5A-5C schematically illustrate a projection surface that may be incorporated with an operational guide system in accordance with the present invention;

[0035] FIG. 6 is a schematic illustration of an alternative operational guide system in accordance with the present invention incorporating a three dimensional spatial motion sensor; and

[0036] FIG. 7 is a schematic illustration of an operational guide system in accordance with the present invention in operation simultaneously guiding activities of multiple individuals.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] The present invention is directed toward advances in an operational light guide system that projects lights to guide actions by one or more individuals, such as the operational guide system disclosed in U.S. Patent No. 7,515,981, which is hereby incorporated by reference.

[0038] With reference to FIGS. 1-2, U.S. Patent No. 7,515,981 discloses an operational guide system or guide system 10 in connection with the providing of visual indicators to an operator 12 performing one or more assembly actions on a work piece 14 at a work station 16 of an assembly line 18. The illustrated guide system 10 includes a controller or a control module 20, two directional light devices 22, 24, a sensor apparatus 26, and a confirmation module or device or element 28, shown as a foot pedal 30. Guide system 10 includes a component location 32, which is illustrated as a parts bin 34, a display device 36, and a tool 38 and tool holder 40.

[0039] Guide system 10 is operable, in response to an operation information or characteristic or identification information associated with work piece 14 detected by sensor apparatus 26, to selectively provide indicating lights 46, 52 to guide an operator in the selection and/or assembly of parts to work piece 14, with the indicating lights 46, 52 being directed and/or provided based on, at least in part, the operation information detected by sensor apparatus 26. The system 10 is also or alternatively operable in response to one or more confirmation signals, such as confirmation signals 48, 56, and/or 84 of FIG. 2 that are described below, which may be manually or automatically supplied to control module 20 to verify completion of a particular operation or task. The system 10 is further operable via display device 36 to

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provide and relay information to operator 12 such as, for example, a listing of steps needing completion, work instructions, images of a work piece, videos, and/or warnings regarding a missed or improperly performed assembly step.

[0040] Referring to FIGS. 1 and 2, when work piece 14 initially enters work station 16, the sensor apparatus 26 detects an operation information or characteristic or identification information associated with the work piece 14, such as, for example, the presence of and/or the type of work piece 14 present at the work station 16. In response to the detection by sensor apparatus 26, a first input signal 42 is communicated or transmitted to the control module 20 and, based on the detected or identified work piece 14 that the operator 12 is or will be working on, the control module 20 communicates or transmits a command signal 44 (FIG. 2) to directional light device 22 to project an indicating light 46 at a location on parts bin 34 to guide the operator 12 to a part required for a particular step in the assembly action. After the proper part has been selected, a confirmation signal 48 (FIG. 2) is sent to the control module 20, the control module 20 then transmits a command signal 50 (FIG. 2) to directional light device 24 to project indicating light 52 to indicate the operational step location 54 on the work piece 14 where the selected component is to be installed. Upon completion of a particular operation step, the operator 12 actuates the foot pedal 30 to transmit a confirmation signal 56 (FIG. 2) to the control module 20 verifying that the operation step has been completed. The control module 20 may then send another command signal 49, 50 to one of the directional light devices 22, 24 to indicate the next operation step, or may release the work piece 14 to a subsequent work station 58, 60 for further operations if all required pick and assembly steps have been properly completed.

[0041] Guide system 10 is able to provide visual indicators to operator 12 that are specific to a particular work piece 14 such that, for example, multiple different styles or types of work pieces requiring different components or parts may be processed at work station 16 with a significant reduction in the risk of the occurrence of assembly errors. The assembly guide system 10 thus provides a cost effective and accurate method of guiding an operator 12 through a series of tasks and provides confirmation that the tasks have been fully accomplished and completed in the proper order. The control module 20 may also be used to monitor cycle times of the individual operational steps and combined operations undertaken at the work station 16 for system productivity reporting, or the like.

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[0042] Assembly guide system 10 is shown in FIG. 1 in connection with work station 16, where work station 16 is part of an assembly line 18 that includes additional work stations 58, 60 for performing subsequent operations. Additional assembly guide systems could be included at the other work stations of assembly line, or a single assembly guide system could be used to aid operations at more than one work station.

[0043] As noted, sensor apparatus 26 functions to detect an operation information or characteristic or identification information associated with work piece 14, such as the presence and/or type of work piece 14 located at the work station 16, and may be constructed as one or more of a number of known sensors such as, for example, a proximity switch, light curtain, photo eye, radio frequency identifier device, bar code reader, or the like. When constructed as a radio frequency identifier device or bar code reader, a readable tag or bar code may be placed on either the work piece or the structure upon which the work piece is supported while traveling on the assembly line. The tag or bar code may contain information regarding the type of work piece at the work station, such as the model of the work piece, measurements related to the work piece, or the type of components required. A scanner or reader may be handheld by the operator or mounted to the assembly line, with the scanner being able to read the information from the tag or bar code when the work piece enters the work station. Alternatively, a sensor apparatus may comprise a vision system configured to detect an identifiable characteristic or identification information associated with a work piece. Guide system 10 may alternatively be activated or sequentially stepped to subsequent operations by non-automated signals. For example, an operator may manually enter a part type into the system, depress a palm button, press a touch screen, or simply commence operations or pre-operations on a part.

[0044] The type of part present at a particular work station need not be determined using a bar code or radio frequency system. For example, and as is known in the art, standard binary type sensors or cameras may be used to detect geometrically distinguishing features of a work piece or the structure upon which it is located to "identify" the work piece. Still further, an assembly guide system could be constructed where an operator uses a hand held scanner to scan a bar code label affixed to the work piece or the structure supporting the work piece as opposed to the scanner being mounted directly to the assembly line. The sensor apparatus may also be used to detect the relative orientation of a work piece with respect to the work station, with the control module adapted to receive the positional information and provide

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accordingly adjusted command signals to the directional light devices such that the projected indicating lights accurately impinge on the desired operational step locations. Still further, the presence of a part at a work station may be supplied to the operational guide system by a manual operator activated input signal, such as by a touch screen, a palm button, or the like.

[0045] Control module 20, in the illustrated embodiment, is a computer controller device and as indicated is adapted to receive and send various signals to monitor and guide the assembly actions at work station 16. Control module 20 may be constructed as a desktop or laptop style PC, a PLC, or the like, or may be a networked computer system that may be used to control and monitor other aspects of the assembly line and work stations.

[0046] As previously indicated, control module 20 is adapted to receive a first input signal 42 regarding identification information of the work piece present at the work station. In the illustrated embodiment of FIG. 1, the first input signal 42 is transmitted to the control module 20 directly from the sensor apparatus 26 along communication link 62, where link 62 is a computer cable, fiber optic line, or the like. Alternatively, however, a first input signal may be transmitted to a network computer system and, in response to the first input signal, the network system may provide the control module with the identification information regarding the work piece present at the work station. The identification information, as previously indicated, may simply indicate the presence of a part at the work station and/or may include information regarding the type of work piece at the work station, such as the model of the work piece, measurements related to the work piece, or the type of components required. Optionally, a sensor apparatus and control module may be alternatively constructed to wirelessly transmit and receive identification information.

[0047] In response to the first input signal 42 received, the control module 20 outputs command signals 44, 50 to directional light devices 22, 24 along link 64 to provide visual indicators to the operator, as described in more detail below, with the command signals 44, 50 being communicated based on, at least in part, the first input signal 42. In the illustrated embodiment, two substantially similar directional light devices 22, 24 are provided at work station 16 and are responsive to the command signals 44, 50 of the control module 20. Directional light device 22 is used to project indicating lights 46 at the component location 32, while the other directional light device 24 is used to project indicating lights 52 at operational step locations 54 on work piece 14. Each directional light device 22, 24 includes a light source 66 for projecting indicating lights 46, 52, with the directional light devices 22,

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24 constructed such that the indicating lights 46, 52 may be selectively and movably positionable to direct the indicating light 46, 52 at pre-targeted locations. The light sources 66 may also be constructed to provide an indicating light beam of selectively adjustable brightness to compensate for ambient surroundings and/or the distance from the light source to the selected impingement point. Although light sources 66 are illustrated in FIG. 1 as projecting a single indicating light beam, it should also be appreciated that light sources 66 may be constructed to simultaneously project two or more beams such that, for example, multiple parts may be indicated for selection from location 32 by the operator 12 or multiple assembly locations may be indicated.

[0048] Light sources 66 may be constructed as laser light sources that are able to project a focused, coherent beam of light at a desired location. Laser light sources may preferably be class 3 or lower lasers for employment within a visual setting for operators. Alternatively, light sources other than lasers may be used and still function as intended, such as standard projectors, incandescent lights, light emitting diodes (LEDs), or the like.

[0049] Light sources 66 may be constructed such that they produce light of differing color from each other to provide further visual cues to the operator 12 while working at work station 16. Furthermore, light sources may be adapted to project animated images or videos onto a surface, such as a surface of the work piece 14, assembly line 18, or a work station 16, 58, 60. The projected animated images or videos may be, for example, a training video, and may be in a .mpeg, .wmv, or other such file format provided by or stored in, for example, a control module of an operational guide system.

[0050] Referring to FIGS. 1A-1L, the directional light devices 22, 24 may also include known optical effect devices for fanning or adapting or configuring the projected indicating lights 46, 52 produced by the light sources 66 into a desired shape, pattern, or form at the point or location at which the indicating light 46, 52 impinges the component location 32 or operational step location 54. For example, the indicating light may initially be projected as a geometric shape (FIGS. 1J-1L), such as a circle, about a particular location to quickly attract the operator's attention, and then focus to a point or circle of smaller diameter at the specific location. The indicating light may also be projected to produce alpha numeric characters, such as shown in FIGS. 1A-1I, blink, and/or produce rotating images. For example, sequential numbers may be projected where each number indicates a step in the assembly action being preformed by the operator at the work station, or part numbers or textual

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information may be projected to provide written guidance to the operator. Indicating lights projected by light sources, as described in more detail below, may further be configured to display videos or pictures or animation on the surface upon which the indicating light impinges. The configured images form a type of display graphic or visual display feature ("VDF") exhibited by an indicating light, such as indicating light 46 or 52, when projected onto a surface, with FIGS. 1A-1L representing exemplary display graphics or VDFs.

[0051] As previously noted, indicating lights 46, 52 may be projected at component location 32 or at operation step locations 54 associated with work piece 14. Component location 32 is exemplified as a parts bin 34 having multiple storage locations 70 for holding various parts required in the assembly of work pieces 14. As shown, directional light device 22 is functional to selectively project an indicating light 46 at discrete storage locations 70 of parts bin 34 in response to command signal 44 to prompt the operator 12 regarding part selection.

[0052] RFID tags, or the like, may also be used to supply information to the control module 20. For example, an RFID tag located on a parts bin 34 may be used in connection with assembly guide system 10 for monitoring the presence and/or proper location of the parts bin 34. In the event assembly guide system 10 detected, such as by control module 20, the absence of parts bin 34 an error message could be, for example, displayed by display device 36, or projected by a light device 22, 24, or an audible warning message may be broadcast.

[0053] In the illustrated embodiment of FIG. 1, storage locations 70 of parts bin 34 include detection devices 72 that are intended to detect or sense when a component has been withdrawn from a particular storage location 70. Detection devices 72 may be of known construction and are selected based on a particular application, taking into consideration the types or models of work pieces 14 and parts to be assembled. Detection devices 72, for example, may comprise light curtains, proximity sensors, electronic mats, such as pressure sensitive mats, machine vision systems, or the like.

[0054] The detection devices 72 are operable to transmit a confirmation signal 48 to the control module 20 along link 74 upon selection by the operator 12 of a part from a particular storage location 70, with control module 20 being functional to determine whether or not the operator 12 has selected the correct part as prompted. In response to the confirmation signal 48, if the operator 12 selected the proper part as directed by the indicating light 46, control module 20 may terminate the indicating light 46 projecting from directional light device 22 at the storage location 70 and transmit a subsequent command signal 50 to directional light

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device 24 to project an indicating light 52 to the operational step location 54 on the work piece 14 where the just selected part is to be assembled. However, if control module 20 determines that an incorrect part has been selected as compared to what should have been selected as prompted by the indicating light 46, control module 20 will not provide the subsequent command signal 50. In addition, control module 20 may be constructed to provide a visual or audible signal to the operator 12 when an improper part has been selected from a storage location 70.

[0055] Although not illustrated, the parts bin may additionally employ a known pick-to-light system whereby each storage location includes an illumination device, such as an LED light or the like, that lights up to prompt the operator as to the proper storage location from where a part is to be selected. When the assembly guide system includes such a pick-to-light system, the directional light device 24 used to project an indicating light 46 at a component location 32 may optionally be excluded.

[0056] As noted above, assembly guide system 10 includes confirmation module 28, which in the illustrated embodiment is a foot pedal 30. Confirmation module 28 is constructed to transmit a confirmation signal 56 along link 76 to control module 20 to signal that the operational step indicated by directional light device 22 or 24 has been completed. To transmit the confirmation signal 56, operator 12 simply depresses foot pedal 30 upon completion of the directed activity. The confirmation signal 56 transmitted by foot pedal 30 then triggers control module 20 to selectively transmit another command signal 44, 50 to provide guidance to the operator 12 regarding the subsequent operational step that must be taken by the operator 12 at the work station 16 in accordance with work piece 14. For example, the assembly guide system 10 may cause an indicating light 46 to be projected at a storage location 70 for the next required part. Alternatively, the control module 20 may provide a command signal that releases the work piece to the next work station 58 if all of the operational steps at the current work station 16 have been completed.

[0057] Although illustrated as a foot pedal 30, it should be understood that numerous alternative confirmation modules 28 may be utilized. For example, confirmation module 28 may be constructed as a pressure sensitive mat, push button, toggle switch, palm button, light curtain, touch screen, touch pad, part present sensor or the like, which is constructed to be depressed, switched, or otherwise activated by a manual action of the operator 12. A sound activated signal may alternatively be employed, such as a voice command, to provide a

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confirmation signal. Confirmation module 28 may also be constructed as a wireless transmitter, thereby eliminating the need for a physical link. Further, operational guide system may be adapted to receive and/or respond to other confirmation signals and/or sources as additional technologies become available.

[0058] Still further, a confirmation module or device or element may be constructed to automatically detect when an operator has completed a manual step. For example, a confirmation module may be constructed as a vision system that is able to detect the presence or absence of a component at a location, such as by processing an image captured by a pixilated imaging device, as is known in the art. Alternatively, for example, the confirmation module may be constructed as a proximity sensor, photo eye, light curtain, or the like, constructed to automatically detect the presence or absence of a part upon assembly to the work piece. Still further, a confirmation signal may be transmitted by an automated tool or measuring device, such as a torque gun, weight scale or other type of measuring device, as described in more detail below. In which case, the automated tool or measuring device may function as a confirmation module. An indicating light projected by a light source of an operational guide system may also be used to provide a confirmation signal where, for example, a sensor is employed at the light source or elsewhere on the operational guide system to detect the reflection of an indicating light from a part or component that requires verification. The light sources may also be used as a "light curtain" by being projected at a particular location or parts bin, or the like, with a sensor adapted to detect that an operator has properly selected from that location.

[0059] It should also be appreciated that an operation information could be transmitted to the controller 20 from a remote signal. For example, in the case of a part kitting operation, an order request may be transmitted to a work station from a central processing location, such as a computer system or the like, and transmit a signal to the work station regarding, for example, what parts to gather and/or assemble. In which case, the work piece of the operation may comprise a collection of parts assembled into a parts holder.

[0060] Although not illustrated, an assembly guide system may also incorporate known ultrasonic, electromagnetic, and/or similar technology used to confirm, for example, that a tool is placed onto the proper bolt or nut at an assembly operation. Such technology is configured to send and receive ultrasonic frequencies with the spatial location of a sent or received signal being monitored to confirm that an operation is performed at a proper

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location. Thus, an assembly guide system may be configured to utilize both light sources and ultrasonic, electromagnetic, and or similar technology to confirm assembly or other manual process steps.

[0061] Assembly guide system 10 also includes a display device 36 that is able to receive display signals 78 (FIG. 2) along link 80 (FIG. 1) from control module 20 and to relay information to the operator 12. Display device 36 may be constructed as a television, LCD, LED device, or other type of viewable display mechanism. Display device 36 may be used to present information to the operator 12 such as, for example, the sequential steps needing to be performed, work instructions associated with the work station 16, images of a work piece 14 properly affixed with the part that is to be assembled, information regarding a missed or improperly performed assembly step, or the like. In the case of sequential steps, display device 36 may be configured to highlight the current step under consideration and/or provide an indication that previous steps have been completed. The display device 36 may be constructed as a touch screen device adapted to be depressed by an operator to provide a confirmation signal regarding completion of a particular step. The inclusion of such a touch screen device may also provide the ability to prompt or guide an operator through certain operational or assembly steps that do not require guidance via indicating light signals. The display device may also be used to show or provide instructional videos, display running cycle times, desired cycle times, and/or alerts, or the like. In the case of a touch screen, the touching by an operator of a particular location or tab area of the screen may display of a video or an image on the display screen, or another display screen, or may initiate the projection of an indicating light or video.

[0062] Optionally, assembly guide system 10 may be used in connection with a tool 38 and a tool holder 40. Tool 38 may comprise, for example, a manual tool such as a wrench, torque wrench, pliers, screwdriver, or the like, or may be an automated tool such as an electric screwdriver, air gun, electric torque wrench, or the like. Tool 38 may otherwise be a manual or automated measuring device such as calipers, a gauge block, feeler gauges, air gauge device, or the like. Tool holder 40 is intended to provide a storage location for tool 38 when tool 38 is not in use. Directional light devices 22, 24 may project an indicating light onto tool 38 and/or tool holder 40 in response to a command signal when tool 38 is required to complete a pending operational step, such as in a similar manner as described above with respect to storage locations 70 of parts bin 34 and operation step locations 54 on work piece

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14. Tool holder 40 may include a sensor and thereby be integrated with the assembly guide system 10 to detect when tool 38 is positioned within or removed from tool holder 40, where the sensor may be a photo eye, proximity switch, light curtain, or the like.

[0063] Although not illustrated, the assembly guide system may utilize an automated gauge or tool that is electrically linked to control module such that control module is able to monitor both the use of the tool as well as an operational parameter associated with the tool. For example, if a tool is constructed as a torque wrench, the control module may be constructed to monitor the fastening torque obtained by the torque wrench and to compare the value to a preprogrammed or predetermined or threshold value prior to transmitting a subsequent command signal. The control thus may function to transmit the subsequent command signal only after the desired or appropriate torque has been applied by the torque wrench. Similarly, if the tool is constructed as a measuring device, such as digital calipers, control module may be constructed to receive a measurement value, and may compare the measurement value to a threshold measurement value, and may communicate or transmit the subsequent command signal when the measurement value is at or near the threshold measurement value.

[0064] Control module 20 is illustrated as transmitting command signal 44a to directional light device 22, which in response to command signal 44a, projects indicating light 46a on storage location 70a of parts bin 34. Upon receiving confirmation signal 48a from detection device 72 signifying that the proper part was selected, control module 20 then terminates projection of indicating light 46a and transmits command signal 50a to directional light device 24 such that indicating light 52a is projected on operational step location 54a on work piece 14 to direct operator 12 as to the proper assembly point for the selected part. Operator 12 then activates foot pedal 30 (or other confirmation device), which transmits confirmation signal 56a to control module 20 and the above process is repeated for indicating lights 46b, 52b, 46c, 52c, storage locations 70b, 70c, and operational step locations 54b, 54c.

[0065] As described in more detail below, the control module 20 and directional light devices 22, 24 of the assembly guide system 10 are programmed as to the proper spatial positioning to where an indicating light 46, 52 is to be projected. This teaching of the assembly guide system 10 may be accomplished in various ways. For example, one teaching method involves the use of known pendant device technology, where the pendant device is used to position the projected beam of the light source 66 to a proper location, such as a storage location 70, record the coordinates, and then move to the next location, such as onto the work piece 14.

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Control module may also be adapted to employ voice activated programming. Alternatively, a wireless transmitter may be used that may be positioned at a desired impingement point of the projected indicating light 46, 52 and functional to transmit the spatial positioning information to the control module. Similarly, various locations, such as part bins, may be provided with wireless transmitters, such as RFID tags, with the control module being adapted to detect the signal and direct the indicating lights accordingly, in which case the operational guide system is able to compensate for movement or shifting of the desired impingement points of the indicating lights. Still further, control module 20 may be directly programmed and, for example, may utilize a touch screen having an image of the work station with the control module 20 being programmable using the touch screen. An operational guide system may also alternatively be programmed via a computer, such as desktop or laptop or networked computer, without the above noted peripheral equipment and using standard hardware such as a mouse to program the control module. The operational guide system may also employ an alignment test pattern that may be used to "calibrate" the system, such as at the beginning of a shift, to insure that the various indicating light signals are properly aimed.

[0066] Guide system 10 also includes cycle time monitoring with display device 36 including display fields which may be used to display to an operator the running time or remaining allowable time associated with performance of an operational step, previous running times, average running times, and/or target times for completion of the operational steps. For example, cycle time monitoring display fields may show the cycle time to perform one or more previous or completed operational steps, while cycle time monitoring display field and/or shows the cycle time of the preceding and current operational cycle. A cycle time measurement may, for example, be initiated upon receipt of a first input signal 42 from sensor apparatus 26, and completed upon detection of a confirmation signal 48, 56, 84. Cycle time measurements of given operations or steps may be recorded and statistically reviewed, such as based on longest to shortest duration, and may be viewed remotely from guide system 10, such as by connecting guide system 10 with a networked computer system.

[0067] As previously noted, control module 20 may also be used to monitor and record various parameters useful for improving productivity. For example, control module 20 may record cycle times of the individual operational steps at a work station 16 and/or the combined cycle time of operations at a work station 16. Correspondingly, control module 20, or another such computational device, may record and provide charts or reports regarding recorded error

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data, such as on mis-performed steps, and/or cycle times. In addition, such data may be linked or otherwise networked, or even monitored via the internet, such that the variously above noted cycle times or performance parameters may be monitored from a remote computer, with such data being viewable in a live format or archived.

[0068] Although not shown, it should also be appreciated that the operational guide system may be adapted to additionally provide audio guidance and/or instruction, such as voice or sound type instruction.

[0069] It should be appreciated that numerous alternative structures and methods are contemplated within the scope of the operational guide system. For example, an operational guide system need only utilize a single directional light device for projecting indicating lights at both a component location as well as operational step locations on a work piece. An operational guide system also need not employ a component location, but rather may employ one or more tools with directional light devices functioning to project indicating lights at the various tools. Furthermore, it should also be appreciated that the assembly guide system 10 of FIGS. 1 and 2 may be alternatively constructed whereby the various links are not formed by computer cables or the like, but are rather formed as wireless connections between the various devices. Still further, each assembly step need not involve both the selection of a part and the assembly of the part to a work piece.

[0070] Operational guide systems may also be incorporated into assembly line systems with the guide systems simultaneously moving along with the item or device being assembled or constructed on the assembly line.

[0071] The operational guide system may also be configured for use with a stand alone work station as opposed to a work station integrated into an assembly line as shown in FIG. 1.

[0072] It should also be appreciated that numerous alternative uses and/or configurations of the operational guide system exist. For example, an operational guide system may be used to pick and package products into a shipping container, such as a bag or box, for fulfilling an order, such as part kitting at order fulfillment centers, supermarkets, part bin loading, assembly line sequencing, product changeovers, or the like. The operational guide system may also be used in a food production or preparation process in which, for example, the indicating lights may be projected onto sequentially required ingredients and may be timed depending upon when a particular ingredient is to be added.

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[0073] FIG. 3 discloses an improved operational guide system 200, where guide system 200 shares similar components or elements with guide system 10, such that not all of the specific construction and alternatives are discussed with regard to guide system 200. Guide system 200 is integrated or interfaced with an operational program system or operational software system or manufacturing execution system (MES) 205 whereby operational software system 205 may provide operational guide system 200 with input signals or data inputs 207 to create, control or cause the projector of operational guide system 200 to project specific display images 209 via the projected indicating light 252 and/or project in specific locations. Manufacturing, production, and/or assembly environments frequently employ operational software systems 205, which are sometimes referred to as enterprise resource planning (ERP) systems, used in association with product planning, production scheduling, inventory control, and the like. These systems are generally defined as control systems for managing and monitoring work-in-process in a factory environment, such as on a factory floor. Examples of such operational software systems include, but are not limited to, SAP ® business software provided by SAP AG of Germany, PROPLANNER ® business software provided by Proplanner Corp. of Iowa, USA, as well as systems such as General Motor Corporation's Global Enterprise Production Information and Control System (GEPICS). Such operational software systems 205 can include data that may be utilized by guide system 200 to assist in guiding the activities of an individual without the necessity of having such information separately programmed or pre-programmed into guide system 200. For example, operational software system 205 may include part or component information, such as bill of material (BOM) information, including information categorized by part or product for separate operational steps in an assembly operation or the like, including part numbers and/or part descriptors, that may be transmitted to guide system 200. Operational software system 205 may also include ordered operational process descriptions as used, for example, for time and cost analysis purposes, which information may also be transmitted to guide system 200. Operational software system 205 may still further include images of parts, components, decals, labels and the like that may be transmitted to guide system 200.

[0074] Accordingly, operational software system 205 may be interfaced with operational guide system 200 as shown in FIG. 3 whereby the data transmitted by operational software system 205 may be directly projected by guide system 200 or used in combination with information programmed into guide system 200 to project indicating lights 246 to create

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desired images 209. Data inputs 207 transmitted by operational software system 205, such as to a control module or controller or guide controller 220 of guide system 200, may be used to create numerous display images 209, including part numbers, part descriptions, work instructions and/or graphics, such as images of parts, decals, or label. As discussed above with regard to the embodiment of FIG. 1, controller 220 includes software for controlling operation of guide system 200, with controller 220 receiving inputs from operational software system 205 directing use and placement of VDFs. For example, data inputs 207 transmitted from operational software system 205 related to part information may be projected or used by guide system 200 to project a particular part number for display to an operator and/or may trigger guide system 200 to project a display image at a particular location wherein a desired part is stored. Data inputs 207 from operational software system 205 related to sequential operational process descriptors may be projected or used to project step-by-step work instructions to an operator for accomplishing a particular task. Graphical data inputs 207 from operational software system may be projected or used by guide system 200 to project a depiction of a part, label, or decal, which may, for example, be displayed to help an individual correctly identify and/or position a particular item. Moreover, the data inputs 207 from operational software 205 may be used and projected with or combined with standard or programmed images, such as images illustrated in FIGS. 1A-1L.

[0075] Referring now to FIG. 3A in connection with the operation of guide system 200, controller 220 is illustrated to include a VDF address table or listing 286, as well as numerous positional identifiers 288 contained in an address table or matrix or positional listing 289. Controller 220 includes numerous pre-programmed VDFs that are each assigned a unique identifier 287, which in the illustrated embodiment for exemplary purposes comprises a horizontal axes with letters "A" to "H" and a vertical axes with the numerals "1" to "7". For example, the textual VDF "Select 1" is associated with the address identifier A1, and the textual VDF "Part 6" is associated with the address identifier F6. In addition to textual VDFs, VDF address table 286 includes images (see A2 to H2), videos (see A4 to H4), and drawings (see A5 to H5). The videos and drawings in FIG. 3A are identified with brackets for explanation purposes, but should be understood that when projected, such as by a projector 266, would form a visual indicator comprising an image, video or drawing, such as a picture or blueprint, on the projection surface. Each unique VDF contains unique characteristic and

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combination of characteristics including, but not limited to, color, font size, font type, width, height, rotation angle, animation type, alphanumeric code, etc.

[0076] In the illustrated embodiment positional listing 289 includes positional identifiers or addresses 288 associated with three separate physical objects, with the objects being identified or represented within positional listing 289 of controller 220 as canvas A, canvas B and canvas C. As shown in the illustrated embodiment, canvas A is associated with positional identifiers PA1 to PA9, canvas B is associated with positional identifiers PB1 to PB16, and canvas C is associated with positional identifiers PC1 to PC16. As described in more detail below, in the illustrated embodiment guide system 200 includes three projectors 266a, 266b, 266c, with each projector being used to project light to form VDFs on the three separate physical objects. The various positional identifiers 288 in listing 289, therefore, represent a location, such as by X, Y, Z spatial coordinates, on the physical object to which a projector and VDFs would be directed. Accordingly, controller 220 is programmed with the locations of nine positions on the physical object associated with canvas A (PA1 to PA9), with the locations of sixteen positions on the physical object associated with canvas B (PB1 to PB16), and with the locations of sixteen positions on the physical object associated with canvas C (PC1 to PC16). Guide system 200 may be taught the positional identifiers in any of the manners discussed above, for example, or utilizing other techniques. Furthermore, multiple projectors may be utilized for each physical object as necessary, with each projector responsible for a specific canvas, or area on the object, and associated positional identifiers.

[0077] With reference to the embodiment of FIG. 3B, three separate physical objects are disclosed, including a parts rack 290, a movable sequence rack 291 that is used to transport parts between parts rack 290 and a vehicle 292, such as may be located on an assembly line. With reference to FIG. 3A, parts rack 290 is the physical object associated with canvas A, sequence rack 291 is the physical object associated with canvas B, and vehicle 292 is the physical object associated with canvas C. Further, projector 266a is utilized to project VDFs onto parts rack 290, projector 266b is utilized to project VDFs onto sequence rack 291, and projector 266c is utilized to project VDFs onto vehicle 292. Parts rack 290 contains nine separate parts bins for containing different parts, with each bin labeled in brackets in FIG. 3B as Part 1 to Part 9 for explanation purposes. It should be understood that this bracketed labeling does not represent the projection of a VDF onto parts rack. Sequence rack 291 includes sixteen separate storage locations within which parts may be stored for sequential

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assembly to vehicle during assembly. Moreover, the nine positional identifiers PA1 to PA9 associated with canvas A correspond to the physical location of each of the nine separate parts bins of parts rack, and the sixteen positional identifiers PB1 to PB16 associated with canvas B correspond to the physical location of each of the sixteen storage locations of sequence rack.

[0078] Thus, in operation, guide system 200 may be prompted to project a particular VDF based on an address identifier 287 onto a surface of a particular object based on a positional identifier 288, with the projected VDF thereby forming a visual indicator on the object. With reference to the embodiment of FIG. 3B, for example, the VDF "Select 3" of address identifier C1 is projected by projector 266a onto parts rack at positional locations associated with the positional identifiers of PA2, PA3 and PA7 to prompt an operator to select three of each of Part 2, Part 6 and Part 7, respectively. Likewise, the VDF "Select 1" of address identifier A1 is projected by projector 266a onto parts rack at the positional location associated with the positional identifier of PA3 to prompt an operator to select a single one of Part 3.

[0079] Subsequent to the selection of a particular part, an operator may be prompted to place the selected part into particular storage locations on sequence rack 291. For example, the VDF "Part 2" of address identifier B6 is projected by projector 266b onto storage locations on sequence rack at the positional locations associated with the positional identifiers of PB1, PB3 and PB6 to create visual indicators and prompt the operator to place one each of the three selected Part 2 type of part into the three separate indicated storage locations. Similarly, the VDF "Part 3" of address identifier C6 is projected by projector 266b onto the storage location of sequence rack 291 at the positional location associated with the positional identifier PB7 to prompt the operator to place the selected Part 3 type of part into the indicated storage location.

[0080] Still further, guide system 200 may subsequently be utilized to aid in the assembly of the parts placed within sequence rack 291 onto vehicle 292, as well as perform additional assembly operations on vehicle 291. For example, VDFs associated with address identifiers B6, C6, D6, F6, G6 and H6 may be projected by projector 266c onto specific locations on vehicle 292 where at the particular selected part is to be assembled in the sequence associated with their storage on sequence rack, with the positional locations for assembly to vehicle 292 being defined by the positional identifiers PC1 to PC16. Still further, additional VDFs may be projected onto vehicle 292, such as are listed as A3 to F3 in VDF address table 286, for example, to direct inspection, alignment, masking or other such operations.

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[0081] It should be appreciated that confirmation signals may be provided with regard to verification that the various activities undertaken by an operator as prompted by guide system 200 were properly completed, such as in the manner disclosed above with respect to guide system 10, such as by a confirmation module. For example, parts rack 290 and/or sequence rack 291 may provide confirmation signals by way of machine vision systems, light curtains, push buttons, as well as spatial recognition systems. Similarly, operations associated with vehicle 292 may similarly be confirmed.

[0082] Accordingly, guide system 200 may be dynamically used to project selected VDFs onto particular locations of an object by selecting a VDF via its associated VDF address identifier 287 and directing a projector 266 to project the selected VDF by a positional identifier 288. This operational approach simplifies the use and employment of guide system 200 by enabling flexible programming to guide system 200, including as may be required due to product and model changes.

[0083] In the embodiment of FIG. 3, data inputs 207 are employed to coordinate the selection of VDFs based on the associated address identifier, as well as the positional location of where the VDF is to be projected based on the positional identifier. Referring now to FIG. 3C, the interface of operational software 205 with the controller 220 of guide system 200 is illustrated. A communication link 293 between system 205 and controller 220 is used for the exchange of data, with communication link 293 comprising a standard communication protocol such as TCP/IP or the like. Controller 220, which includes hardware and software, includes an application program 294 for interfacing with the operational software 205, where application program 294 may be customized based on the specific type or program of operational system 205 employed. Also included is a guide system program 295, with guide system program 295 including the above noted address table 286 and positional listing 289. In one embodiment application program 294 and guide system program 295 may interact via an application programming interface (API) such as Windows Communication Foundation (WCF). Accordingly, guide system program 295 of guide system 200 can be utilized with multiple different operational software systems 205 based on the customization of application program 294 for the particular operational software system 205 employed. Data inputs or signals to controller 220, such as signals representing part numbers, product model numbers, operational steps, and the like, are interpreted by controller 220 via application program 294

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and guide system program 295 to cause the proper selection of a VDF based on the address identifier and project it at the appropriate location based on the positional identifier.

[0084] As previously noted, operational systems 205 may include detailed information regarding production processes, including the location and status of particular objects being assembled, as well as the parts required to be assembled. For example, operational software systems 205 can track the model and location of a vehicle on an assembly line and thereby interact with guide system 200 in the manner described above to coordinate the providing of the appropriate components and assembly actions. Thus, operational software system 205 may provide data streams of input signals 207 to guide system 200 to enable desired VDFs to be projected at desired locations. Interfacing guide system 200 with operational software system 205 reduces the amount of separate programming required for guide system 200, as well as enables real time or dynamic creation of visual indicators or display images 209 for guiding the activities of an individual. Thus increasing the flexibility of guide system 200 based on changing operational requirements of an assembly, inspection or other process requiring guidance assistance via guide system 200.

[0085] With further reference to FIG. 3, a sensor apparatus 226 may be provided, such as sensor apparatus 26 described above in reference to FIGS. 1 and 2, that may be used for triggering or sending data inputs to guide system 200 for part selection and/or confirmation. For example, upon activation of guide system 200 to perform a particular guidance procedure based on detection of a component or required assembly or inspection steps, sensor apparatus 226 may transmit a signal 211 to operational software system 205 identifying the particular component or required assembly steps pending at guide system 200. Operational software system 205 may then transmit data inputs 207 based on signal 211. Alternatively, in response to an input signal 242 transmitted by sensor apparatus 220 to guide system 200, such as to a control module of guide system 200, guide system 200 may send a signal 213 to operational software system 205 triggering the transmission of data inputs 207 to guide system 200 based on the particular component or required assembly or inspection steps pending at guide system 200. Still further, operational software system 205 and guide system 200 may be integrated or interfaced in such a manner that data within operational software system 205 is provided to or resides within guide system 200 without the need for triggering signals. As noted, sensor apparatus 226 may be a sensor apparatus component of guide system 200. Alternatively, sensor apparatus 226 may be a separate component, such as a device that detects the presence

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and/or type of product at guide system 200, or may be a device such as a computer for allowing manual inputs.

[0086] Although described above in regard to the assembly of a vehicle, it should be appreciated that guide system 200 may be employed with numerous alternative processes, including assembly, inspection, sequencing, product changeover, welding, stamping, part kitting, and the like. Moreover, the guide system may include fewer or substantially more VDFs, with each having its own address identifier, as well as include additional positional identifiers. It should be further understood that numerous alternative VDFs may be employed, as well as that multiple VDFs may be simultaneously projected or projected sequentially as desired. For example, a VDF may be projected to form a visual indicator that traces a route along an object, as well as traces a route along an object at a particular speed. Such a visual indicator may be used, for example, to aid in the application of an adhesive onto the object by enabling an operator to follow the indicator to place the adhesive in the appropriate location, as well as in the proper amount based on the speed of the projected visual indicator. Still further, a guide system may include fewer or more projectors and/or enable a single projector to project onto multiple physical objects.

[0087] Although shown in connection with an operational software system in FIGS. 3 and 3C, it should be further appreciated that guide system 200 may be employed utilizing an addressed VDF listing 286 and positional identifiers 288 without an operational software system 205 and/or without a system controller as described below. In such embodiments, guide system controller 220 may be programmed by selecting VDFs to be projected based on the VDF address identifiers and the positional identifiers corresponding to the locations on a physical object, thereby providing substantial flexibility to the programming of guide system controller 220. In such an embodiment, guide system controller 220 may receive input signals directly from a sensor apparatus and/or via manual inputs from an operator.

[0088] Still further, as illustrated in FIG. 3D, guide system controller 220 may be configured for operations through a system controller 296, such as a PLC device, where the system controller 296 may operate to control an automated process, such as an assembly line 18, and provide input signals 207 to controller 220. In such an arrangement system controller 296 may communicate with controller 220 via an I/O fieldbus interface. For example, system controller 296 may receive signals 297 from a sensor apparatus, such as a bar code reader or the like, as described above in connection with system 10, and in turn provide an input signal

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207 to guide system controller 220 to prompt the projection of a VDF based on an address identifier 287, at a particular physical location based on a positional identifier 288. It should be appreciated that application program 294 and/or guide system 295 may operate to parse or interpret the data inputs 207 to prompt selection of the appropriate address identifier and positional indicator. An alternative system controller may be employed comprising a software system, such as a soft-PLC or visual logic controller (VLC) software, or the like for example, in which case a hardware system employed with a conventional PLC device may not be required. In such a software based application the system controller may reside and operate on the guide system controller 220.

[0089] In turn, as illustrated in FIG. 3D, an operational software system 205 may provide communications to a system controller 296 that is utilized to control operation of an automated process, such as assembly line 18, as well as guide system 200. It should be appreciated with respect to FIG. 3D, however, that guide system 200 may be controlled and interact with system controller 296 without utilizing an operational software system 205. For example, system controller 296 may receive signals 297 with regard to an operational process, such as via a bar code or data reader or other such sensor, with the PLC in turn providing input signals 207 to guide system controller 220 of guide system 200 based on such signals, and with the input signals 207 being parsed or interpreted by the guide system control 220 to define the appropriate addressed VDF and positional identifier.

[0090] Thus, it should be understood that guide system controller 220 of guide system 200 may receive input signals triggering the selection of address identified VDFs and positional identifiers for directing the projection of the selected VDFs onto a desired location of a physical object from a variety of equipment, controllers and systems. For example, the input signals may be provided to the controller 220 directly from an operational system 205, where the operational system 205 may itself receive signals from a sensor apparatus 226 and the input signal provided by the operational system 205 are based on the signals received by the operational system 205 from the sensor apparatus 226. Input signals triggering such projection by guide system 200 may also or alternatively be provided directly to guide system controller 220 by a sensor apparatus 226. Still further, a system controller 296 may provide input signals triggering projection, including via the system controller 296 receiving signals from a sensor apparatus 226. It should further be appreciated that in like manner to system 10, guide system 200, including whether used as a stand alone system or in connection with a

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system controller 296 and/or a manufacturing execution system 205, may receive confirmation signals upon completion of an activity directed by a projected visual indicator, such as via the above noted techniques, including via a confirmation module 228. That is, confirmation signals may be provided directly to guide system controller 220, such as via a confirmation module 228 and/or confirmation signals may be provided to guide system controller 228 from a system controller 296 and/or an operational system 205. These various alternatives regarding input signals, confirmation signals, a sensor apparatus 226, and a confirmation module 228 are schematically illustrated in FIG. 3E, wherein it should be appreciated that the system controller 296 and/or operational system 205 may be omitted.

[0091] Referring now to FIG. 4, an operational guide system 300 is illustrated, where guide system 300 shares similar components or elements with guide system 10, such that not all of the specific construction and alternatives are discussed with regard to guide system 300. Guide system 300 includes an integrated camera device 313 that may be used to record and/or review activities by an individual being guided by guide system 300, as well as the object that is the subject of activities by the individual. Camera 313 may be a digital camera for still pictures or a video recorder, such as a webcam or a high definition video camera recorder, including a video camera capable of capturing still images. Images or videos captured by camera 313 may be recorded or stored in guide system 300 and subsequently viewed on a display device 336 of guide system 300 and/or on a separate display device remote from guide system 300, such as via a computer network. Such images or videos may be used for numerous process analysis purposes, including to develop process improvements, such as facilitating assembly steps, determine or investigate why certain operational steps exceeded a desired cycle time, and monitor causes of downtime. Images recorded by camera 313 may also be viewed in combination with recorded cycle time data to review the recorded process steps and determine corrective actions to optimize the process and/or reduce cycle times.

[0092] Still further, recorded and/or real time images from camera 313 may be viewed remotely from guide system 300, such as by interfacing guide system 300 with a monitor 315, where monitor may be (part of) a computer 317, for example, integrated with guide system 300 through an intranet or internet connection, including via a wireless connection. Computer 317 may also be used to control various aspects of guide system 300, including camera 313 and a directional light device 322 having a projecting light source. For example, in one scenario guide system 300 may be used as part of a remote training session whereby a trainer

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remotely located from guide system 300 may train one or more students at a remote training station utilizing guide system 300. In such a scenario, the surgeon may view with computer 317 the object being worked on by the students via camera 313. The trainer may then control directional light device 322 by a light controller 319, such as a joystick, to project an indicating light onto a particular location of the object at the training station for directing activities of the students. In such an embodiment, guide system 300 may also include a camera controller 321, such as a separate joystick or the like, whereby the surgeon may also control aspects of the camera 313, such as the camera's viewing position, focus, and zoom. Although light controller 319 and camera controller 321 are illustrated as separate components, it should be understood that computer 317 may be used to control the directional light device and/or camera 313 without separate components. In another scenario, camera 313 may be used by a technician or engineer during programming of guide system 300, such as to program a new assembly step whereby the camera 313 would allow the programmer to view, for example, the work station and any associated part bins and properly direct the projection of an indicating light by directional light device 322.

[0093] Camera 313 may be a separately mounted camera, such as at a fixed position or mounted for movement, such as by servo motors. Still further, camera 313 may be integrated with the directional light projecting devices.

[0094] Referring now to FIGS. 5A and 5B, a directional light device 22 having a light projector 66 is illustrated relative to work station 16, such as shown with reference to operational guide system 10 and work station 16 of FIG. 1, where indicating lights projected by the light device 22 are directed at a projection surface or screen 71. Projection surface 71 allows individuals to view display images 209 projected onto surface 71 when the individuals are located on the opposite side of projection surface 71, such as when an individual is standing at work area 77, relative to directional light device 22 and may be utilized, for example, in locations in which a light projector is constrained from projecting indicating lights without being blocked by an operator or additional equipment or by components located at the work station. Images 209 projected onto a back surface or rear surface 73 of projection surface 71 are viewable by an operator stationed at work station 16 when the operator views the front surface 75 of projection surface 71 such that the operator may see and read display images 209, such as words, pictures, or videos, for guiding activities at work station. Projection surface 71 may be constructed from a conventional rear projection screen.

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[0095] FIG. 5C illustrates an alternative embodiment in which projection surface 71 is mounted to work station 16 with light device 22 and light projector 66 mounted from beneath. In the embodiment of FIG. 5C, an operator stationed at work station 16 views on front surface 75 display images 209 projected on back surface 73. As illustrated, projection surface 71 may be angled or angularly inclined, such as in the range of approximately 20 to 25 degrees relative to a horizontal plane, for ease of viewing by the operator.

[0096] Although projection surface 71 described above is constructed as a rear projection screen, it should be appreciated that in an alternative embodiment a projection surface may be employed in which a directional light projection device projects images directly onto the surface viewed by an individual as opposed to the rear surface. In such an embodiment, the directional light projection device may be located above or to the side of the individual being guided.

[0097] With reference to FIG. 6, an operational guide system 400 may also be constructed to include one or more three dimensional spatial motion sensors 423 for monitoring activities of an operators body, hand, etc. and/or other surfaces related to robots, workstation hardware such as fixtures, part bins, etc. to confirm that desired operational steps are properly accomplished. Sensor 423 may, for example, be used to or as part of monitoring that particular parts were properly selected from the correct bins and placed for part kitting purposes or assembled to a work piece. Sensor 423 may additionally function as a confirmation module, such as confirmation module 28 discussed above, to provide output confirmation signals 456 comprising data related to the detected motion sensed by sensor 423, such as to guide controller or guide control module 420, where the detected motion data may be compared to predetermined required motions or actions to thereby aid in indicating or determining that the operational step indicated by the directional light device of guide system 400 has been properly completed. Alternatively, motion sensor 423 may itself include processing capability for comparing detected motion to a predetermined desired action to thereby provide a confirmation signal 456 if the guided action has been properly completed. In situations where the motion detected by sensor 423 does not match a predetermined action a signal may be transmitted, such as by a guide system controller or the sensor itself, indicating as such.

[0098] Sensor 423 may, for example, employ Microsoft Corporation's KINECT three dimensional spatial motion sensor technology, which utilizes a three dimensional infrared

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laser projector and a monochrome CMOS sensor for analyzing depth, as well as a separate RGB video camera. Details of such technology may be disclosed in U.S. Pat. Nos. 7,763,841 titled OPTICAL COMPONENT FOR A DEPTH SENSOR and 6,963,060 titled PHOTO-SENSOR ARRAY FOR MOTION DETECTION, the disclosures of which are incorporated herein by reference. However, it should be understood that alternative three dimensional spatial motion sensor technology may be employed with sensor 423. Still further, sensor 423 may include a camera that is additionally utilized to record and/or review activities by an individual being guided by guide system, such as camera 313 of guide system 300 of FIG. 7. Accordingly, it should be appreciated that the sensor 423 of guide system may be used for process analysis purposes, remote user interface and/or programming purposes, as well as for confirmation of proper completion of guided operations.

[0099] FIG. 7 illustrates an operational guide system 500, which may be any of guide systems 10, 200, 300 or 400 described above, in operation simultaneously providing indicating lights to guide activities of multiple individuals 512a, 512b, 512c, 512d. As illustrated, guide system 500 includes a single controller 520 with multiple projectors 566a, 566b, 566c, 566d and multiple sensor apparatuses 526a, 526b, 526c, 526d. Each projector 566 may be used to guide one or more actions by a separate individual 512, where the actions for each individual 512 may be guided completely separate or independently of the guiding of actions for the other individuals. For example, if each individual 512 is performing the same task, but each individual performs the task at a different rate, guide system 500 can accommodate such variation and allow each individual to initiate, perform, and finalize their activities separately from one another. Alternatively, one or more of the individuals 512 may be directed by guide system 500 to perform separate tasks requiring different guided activities that may be initiated, performed, and completed independently from the guided activities for the other individuals. Accordingly, operational guide system 500 may be provided with, as shown, separate sensor apparatuses 526a, 526b, 526c, 526d and/or confirmation modules 528a, 528b, 528c, 528d associated with each individual 512a, 512b, 512c, 512d, respectively. Furthermore, these system improvements may also be used by guide system 500 to project the VDFs required to guide process steps for multiple individuals from one projector rather than multiple projectors.

[00100] Operational guide systems 200, 300 and 400 of FIGS. 3-6 may be similarly constructed to operational guide system 10 discussed above, with similar components to

Amazon Ex. 1002.0044

operational guide system 10 being identified with 200, 300 and 400 added to the reference numerals of guide system 10, and such that not all of the details of similar features are discussed with reference to guide systems 200, 300 and 400.

[00101] In addition, guide systems in accordance with the present invention may include a conditional programming methodology whereby the guide system controller enables and/or provides a user, system controller, or manufacturing execution system to re-direct the guide system based on a signal received by the guide system controller. For example, if a sensor apparatus detects that a guided operation was missed or not done properly, the guide system may provide specific remedial guidance based on that detection. Examples include, but are not limited to, rework requirements, help information, and missing parts options. If, for example, a vision system sensor detects that a part is missing or a gauge tool sensor detects that a part is out of specification, guide system may provide remedial guided actions to correct the error.

[00102] The guide system of the present invention thus is readily programmable and adaptable to provide a cost effective and accurate method of guiding an individual through a series of tasks and/or provide confirmation that the tasks have been properly completed.

[00103] Changes and modifications in the specifically described embodiments can be carried out without departing from the principles of the present invention which is intended to be limited only by the scope of the appended claims, as interpreted according to the principles of patent law including the doctrine of equivalents.

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CLAIMS

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A guide system adapted to provide visual indicators to an individual to guide actions for a particular guided operation, said guide system comprising:

a directional light device, said directional light device being selectively operable to project and target at least one indicating light;

a guide system controller, said guide system controller being operable to control said directional light device to project a visual indicator onto a physical object associated with the particular guided operation;

a camera located proximate to said directional light device and configured to image said visual indicator when projected onto the physical object;

a monitor, said monitor being remote from said directional light device and said guide system controller, with said monitor being operably interfaced with said camera to display images from said camera.

2. The guide system of claim 1, wherein said guide system controller is configured to be selectively interfaced with a computer, said computer being remote from said directional light device and said guide system controller, with said monitor interfaced with said computer and with said computer configured to selectively operate said guide system controller.

3. A method of projecting visual indicators to guide actions of an individual for a particular guided operation, said method comprising:

projecting a visual indicator using a directional light device onto a physical object associated with the particular guided operation;

imaging the projected visual indicator with a camera located proximate to the directional light device;

transmitting images from the camera to a monitor located remotely from the directional light device; and

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displaying images from the camera on the monitor.

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ABSTRACT

A guide system and method of projecting visual indicators onto a physical object to guide actions of an individual comprises providing a guide system having a guide system controller and a projector, with the guide system controller including a plurality of addressed display features. An input signal is provided to the guide system controller whereby an addressed display feature is selected based on the input signal and the projector projects a visual indicator corresponding to the selected addressed display feature onto a physical object. The guide system controller may also include a plurality of positional identifiers, with the method including the selecting of a positional identifier based on the input signal and the projecting of the visual indicator onto a physical object at a location corresponding to the selected positional identifier.

Amazon Ex. 1002.0048

Prior Art

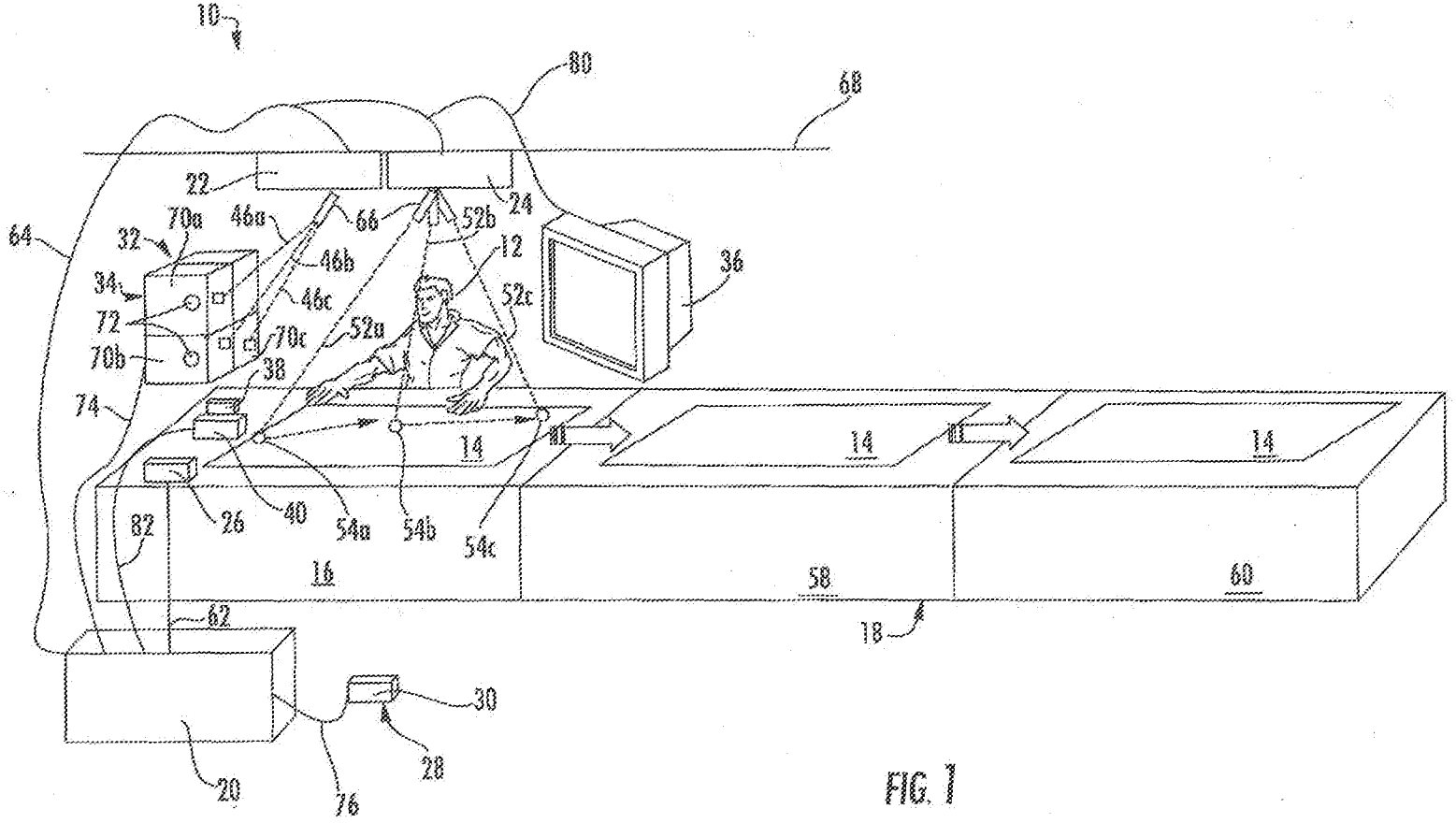


FIG. 1

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Pre-assemble

> <

FIG. 1A

Select

FIG. 1B

Insert

FIG. 1C

Assemble

FIG. 1D

Pick

FIG. 1E

Gauge

FIG. 1F

Torque

FIG. 1G

Left

FIG. 1H

Right

FIG. 1I

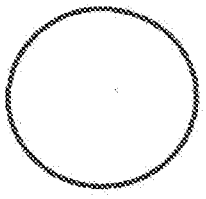


FIG. 1J

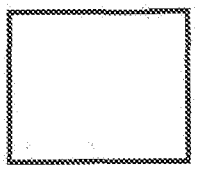


FIG. 1K

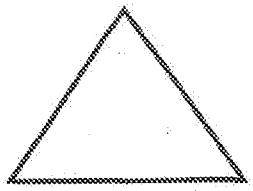


FIG. 1L

Prior Art

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Prior Art

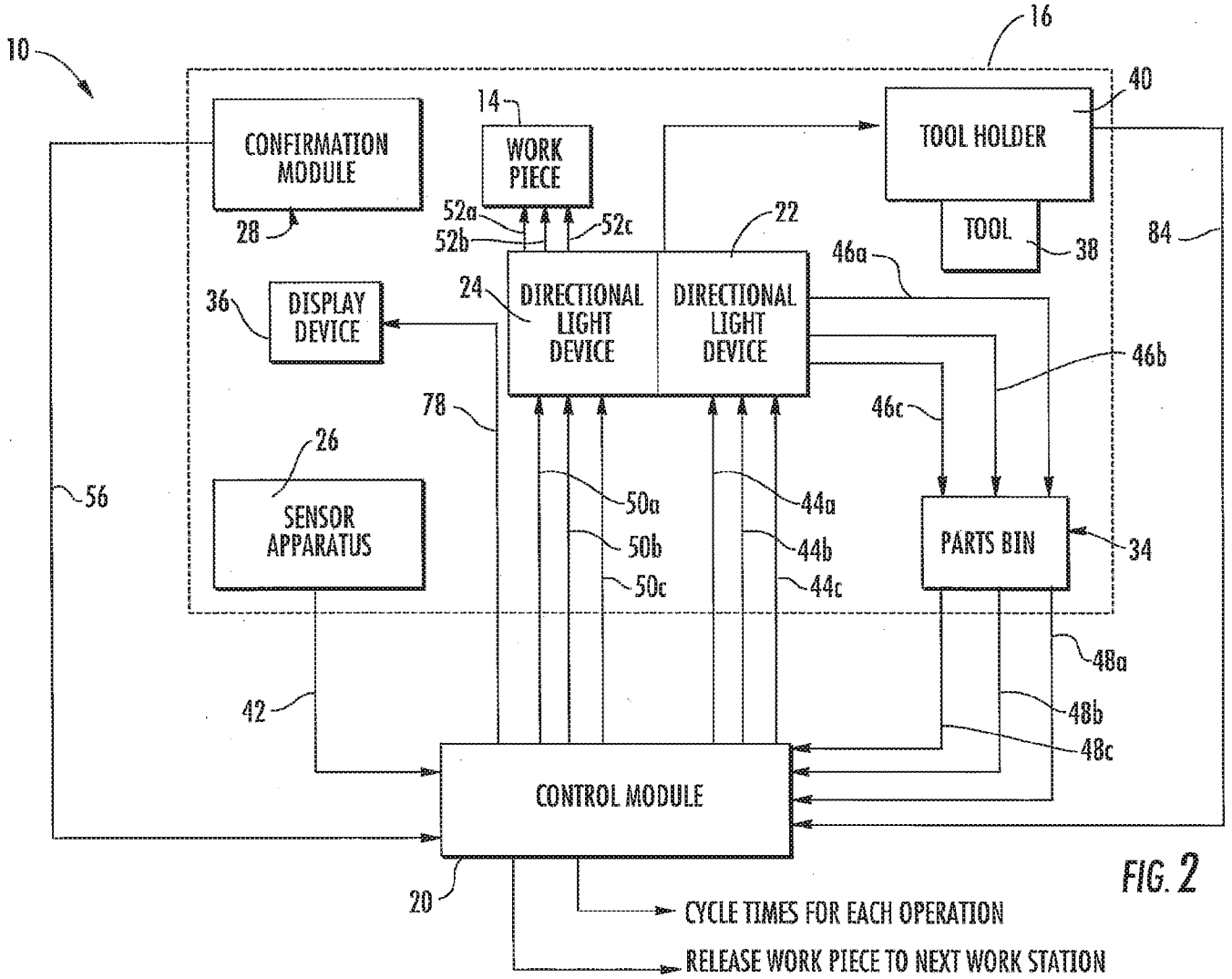


FIG. 2

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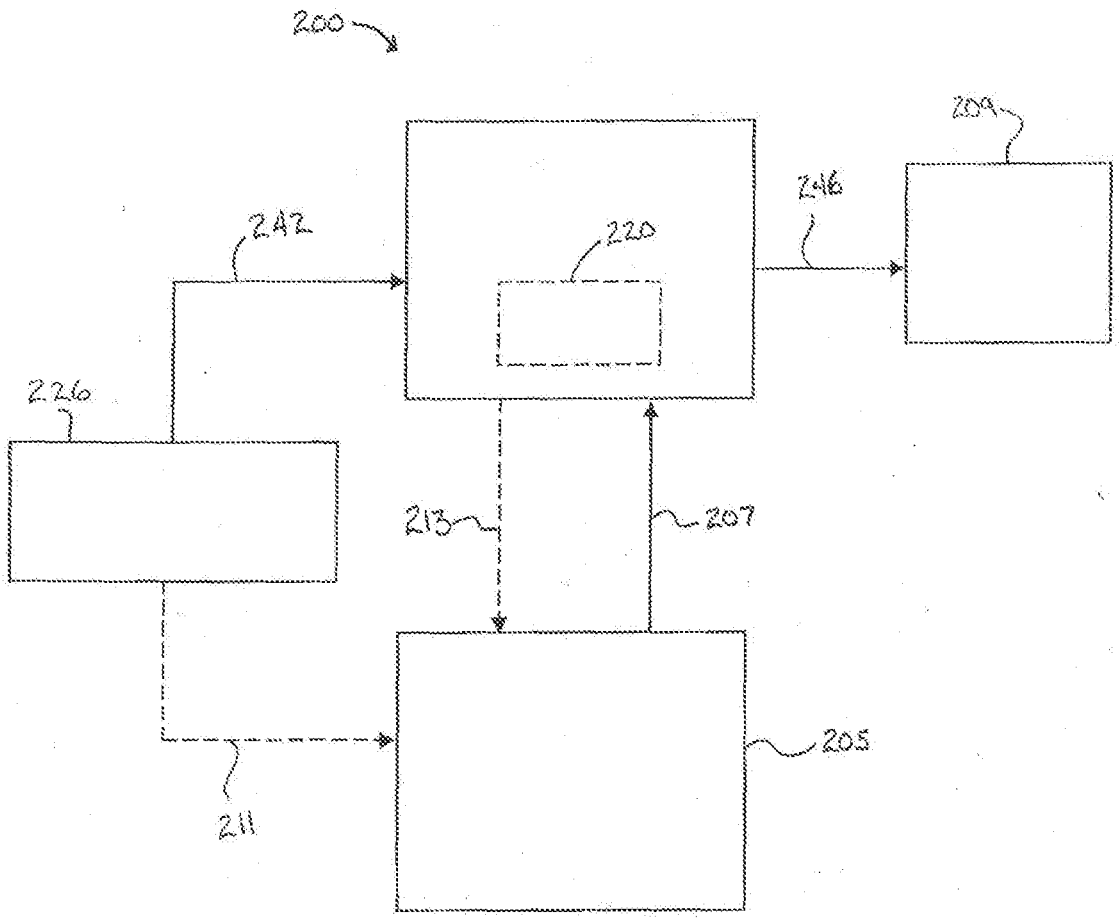


FIG. 3

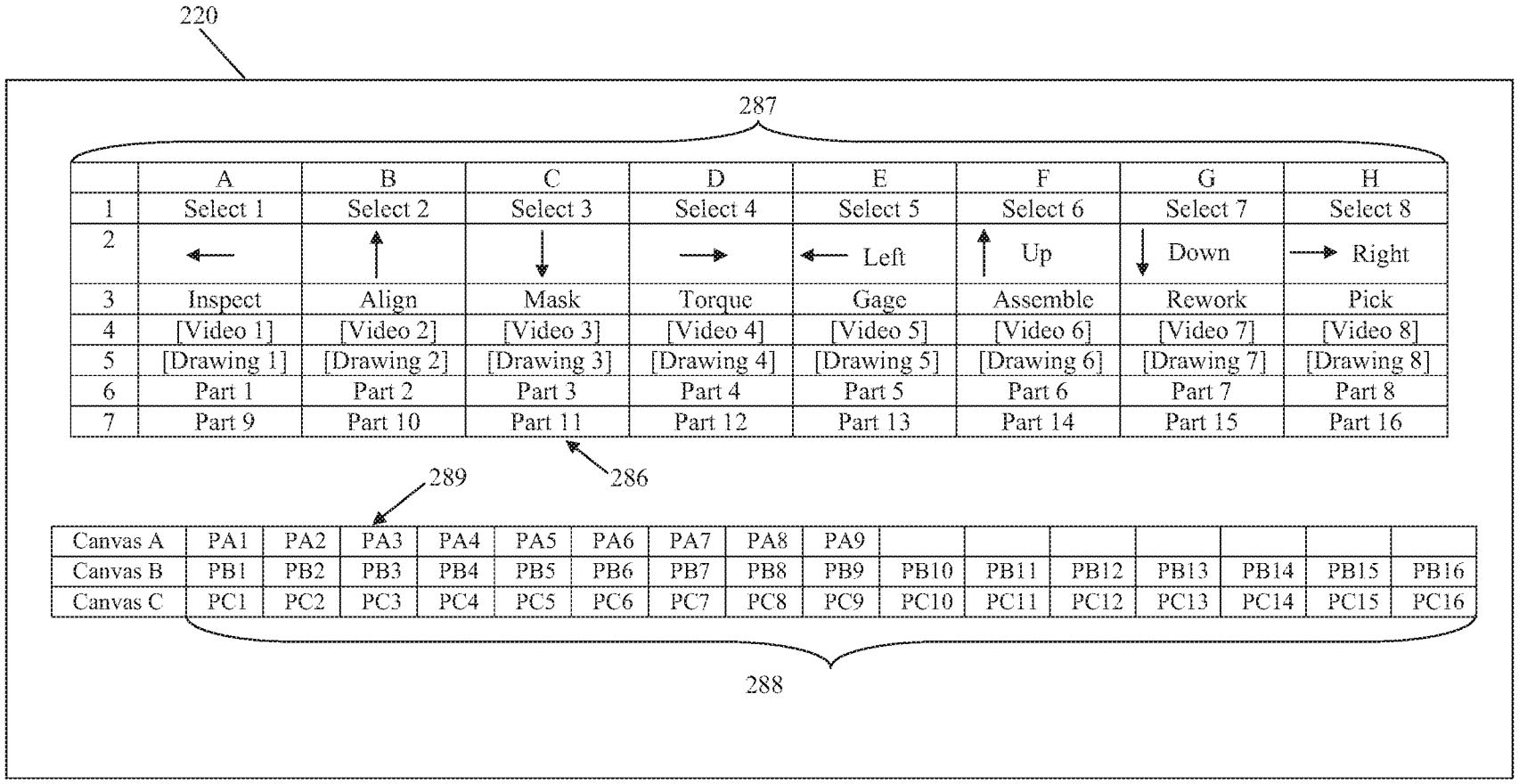


FIG. 3A

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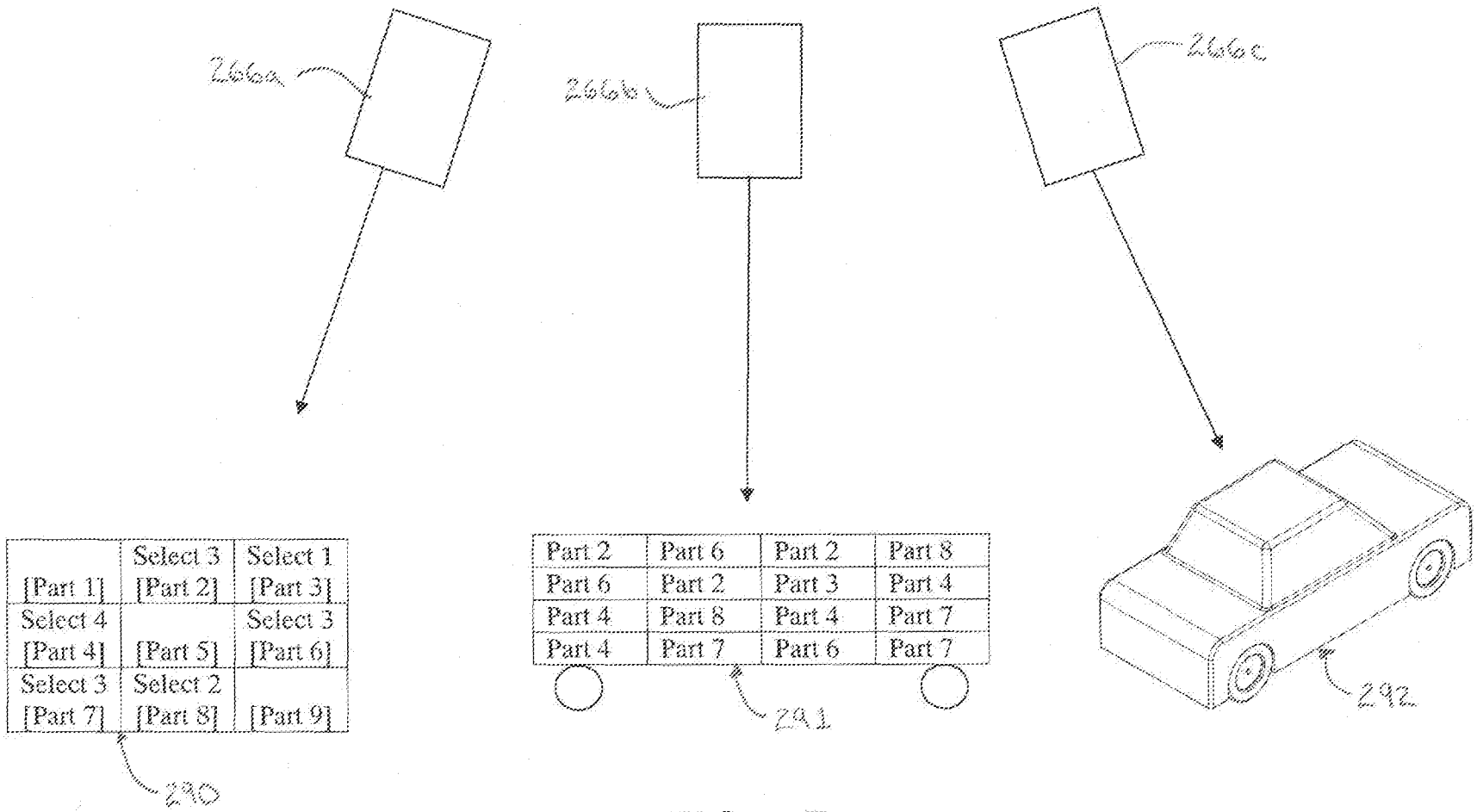


FIG. 3B

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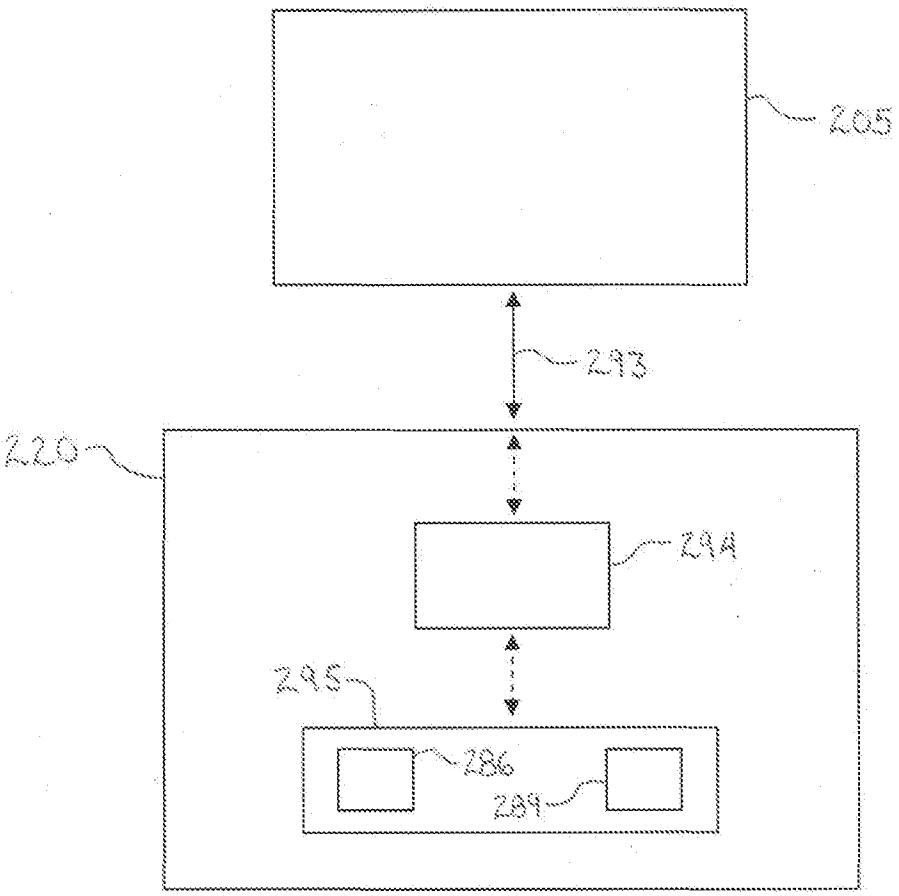


FIG. 3C

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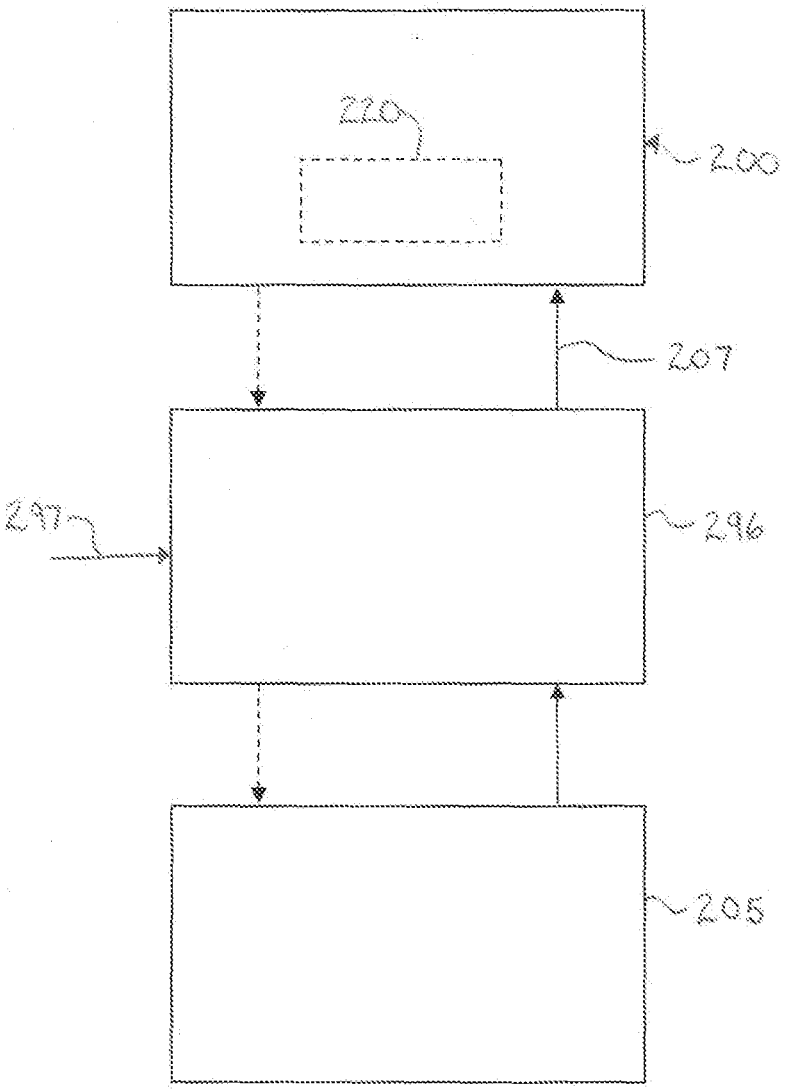


FIG. 3D

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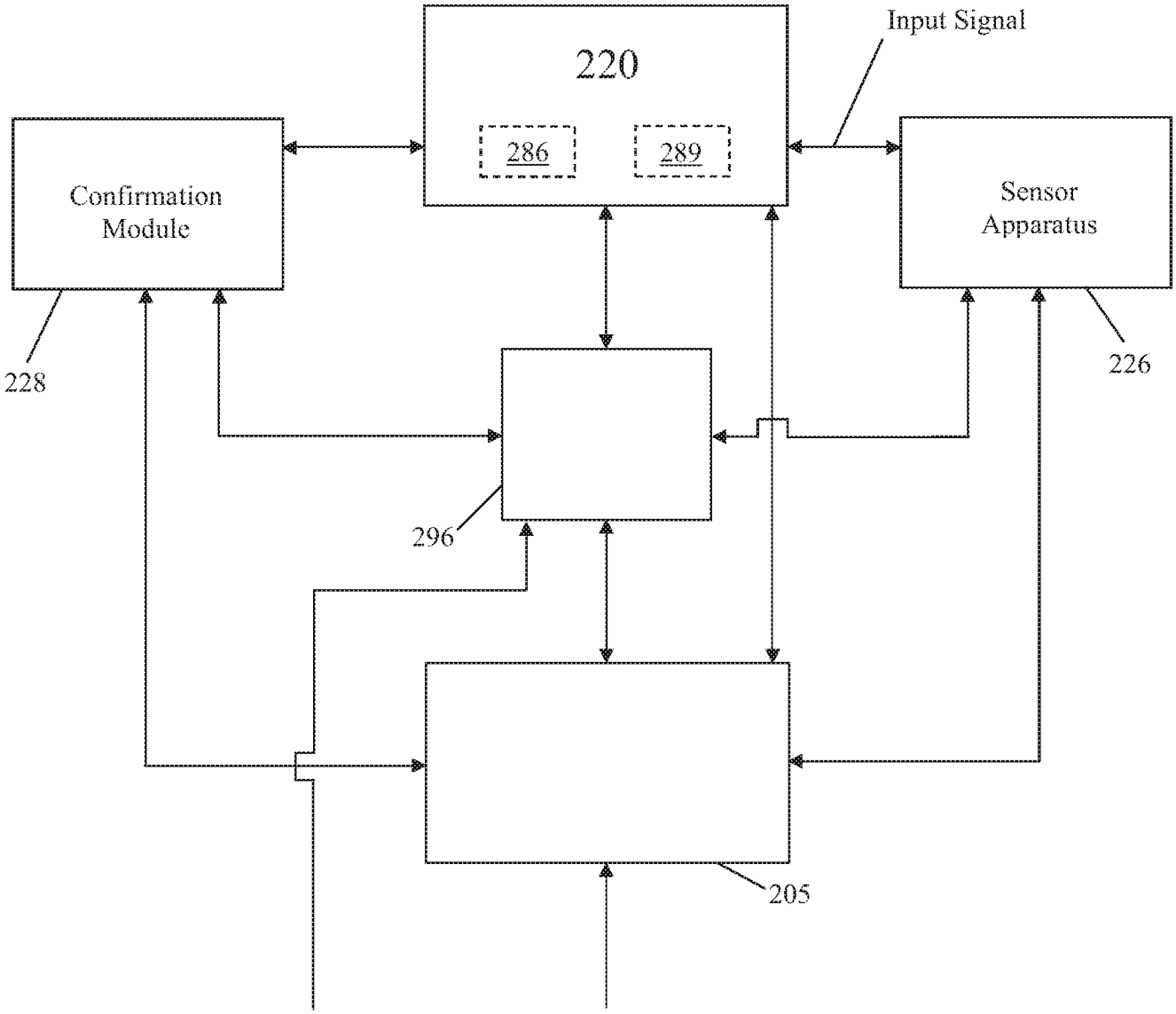

220
286
289
Input Signal
Confirmation Module
Sensor Apparatus
228
226
296
205

FIG. 3E

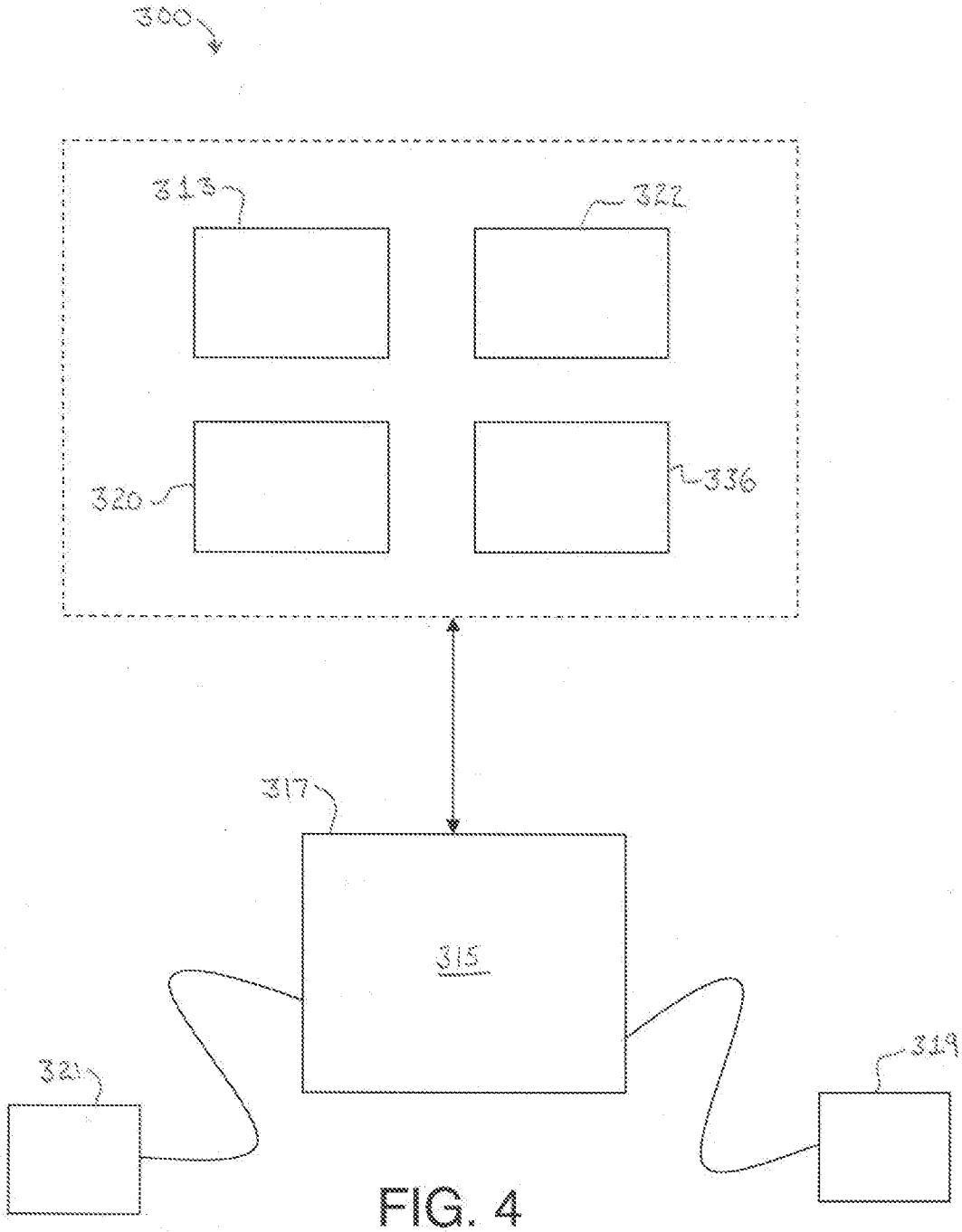


FIG. 4

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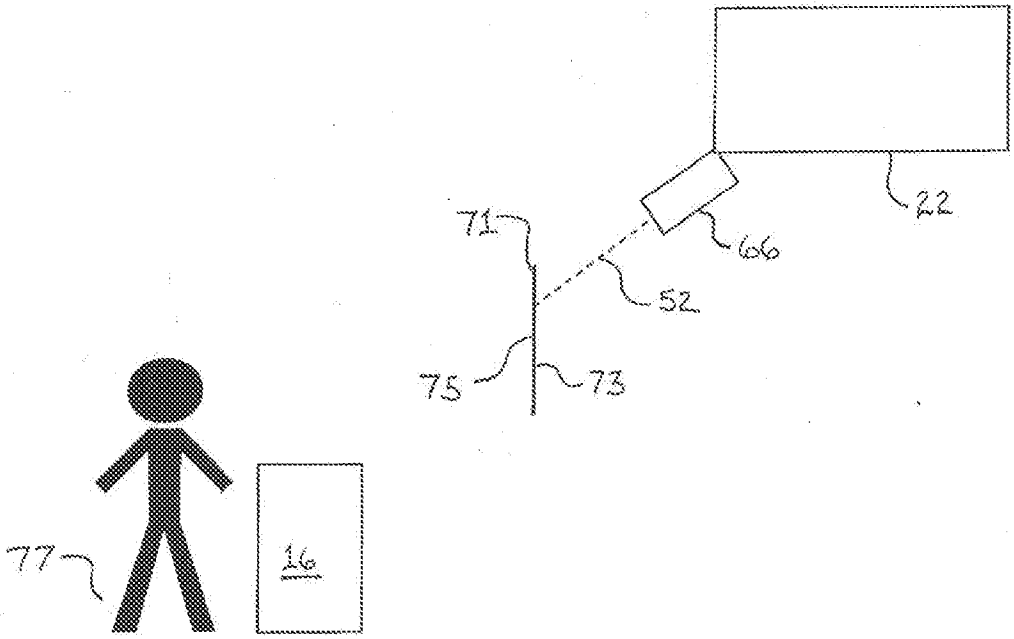


FIG. 5A

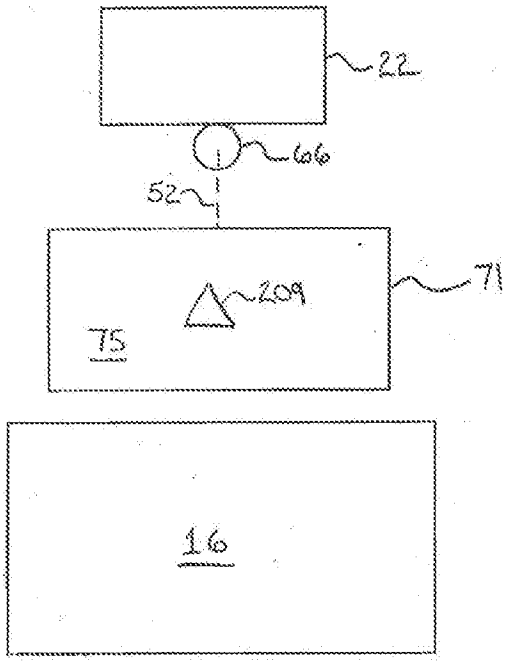


FIG. 5B

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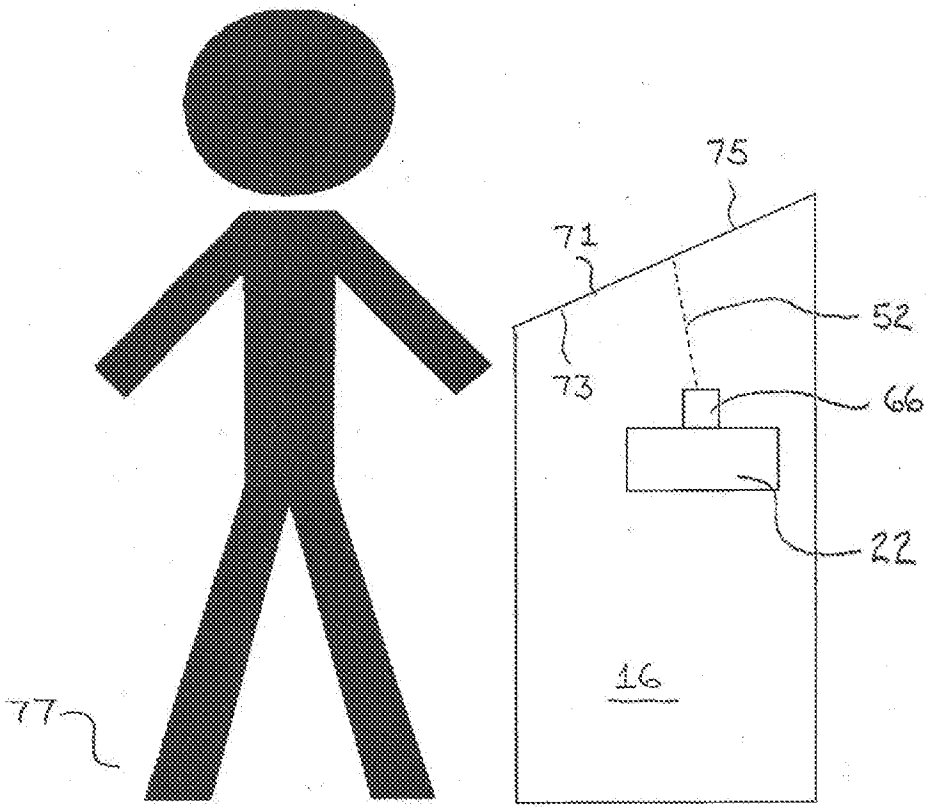


FIG. 5C

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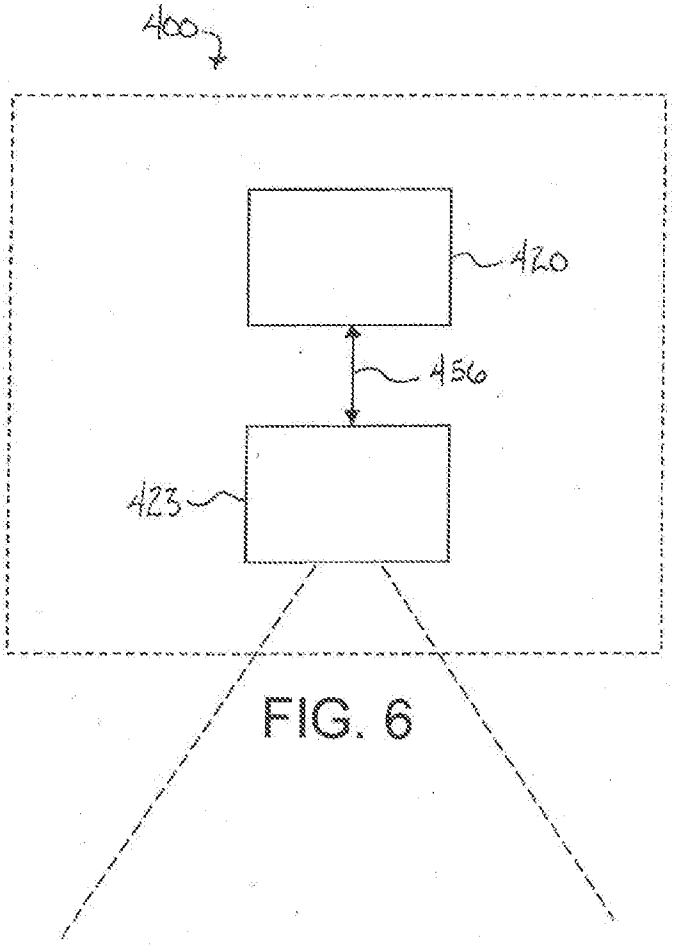
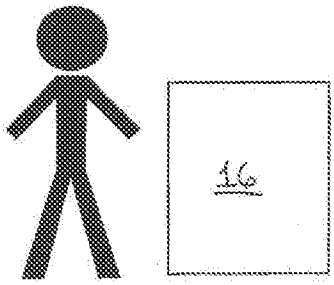


FIG. 6



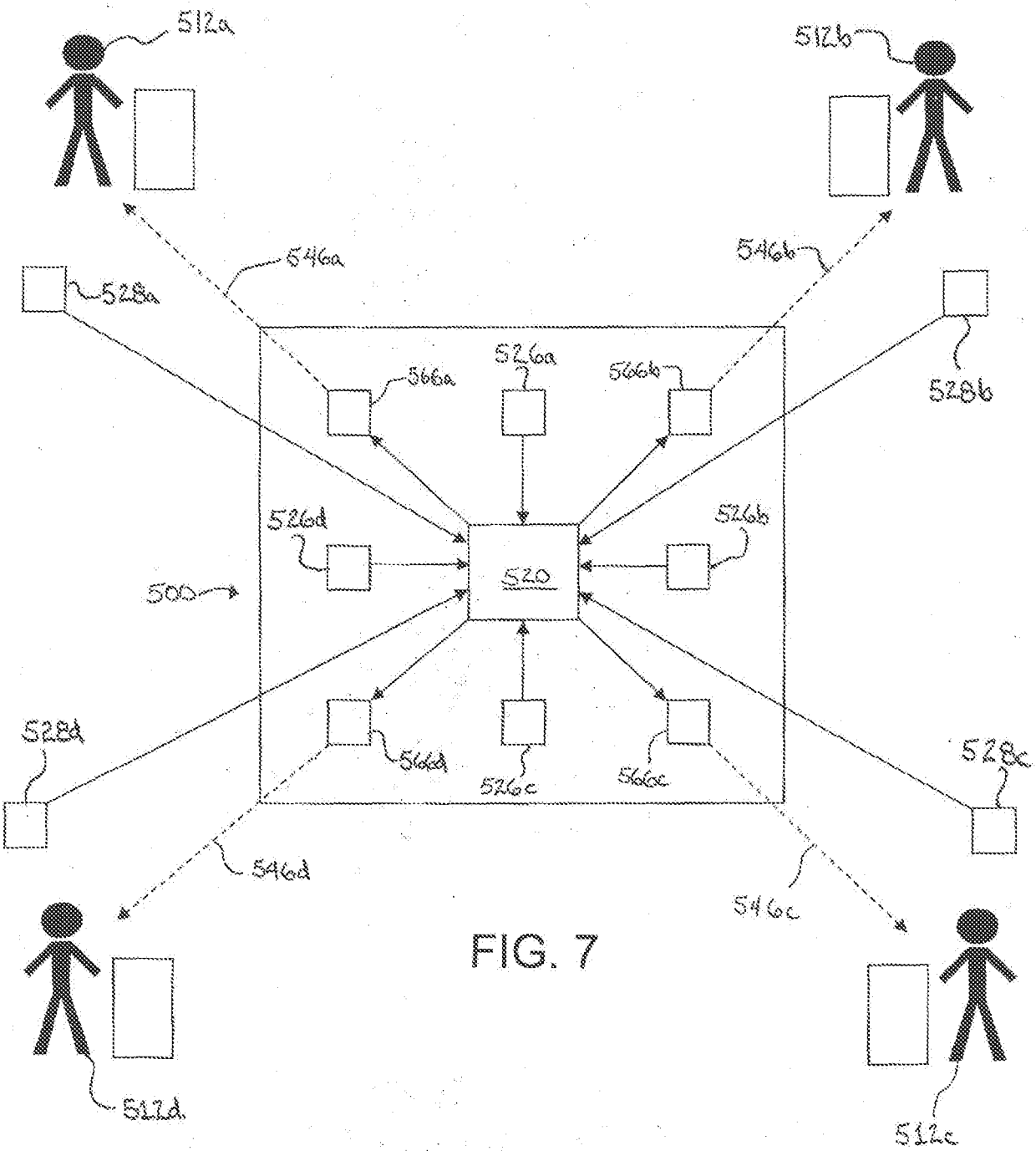

512a
512b
546a
546b
528a
528b
526a
566a
566b
526d
526b
500
520
528d
528c
566d
526c
566c
546d
546c
512d
512c

FIG. 7

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Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

As the below named inventor(s), I/we declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number PCT/US2012/024730

filed on February 10, 2012

☐ As amended on _____ (if applicable);

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought;

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application. The above-identified application was made or authorized to be made by me/us.

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FULL NAME OF INVENTOR(S)

Inventor one: Paul Ryznar Date: August 8, 2013

Signature: _____ Citizen of: US

Inventor two: James Ryznar Date: August 8, 2013

Signature: _____ Citizen of: US

☐ Additional inventors or a legal representative are being named on _____ additional form(s) attached hereto.

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First Named Inventor	Paul Ryznar et al.
Art Unit	
Examiner Name	
Attorney Docket Number	RYZ01 P-101B

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	1	7515981	B2	2009-04-07	Ryznar et al.	
	2	4222036		1980-09-09	Troukens	
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	8	3600785		1971-08-24	Cook	

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	Examiner Name	
	Attorney Docket Number	RYZ01 P-101B

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	Examiner Name	
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	20	7268893	B2	2007-09-11	Palmateer	
	21	5406176		1995-04-11	Sugden	

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	3	20040111901	A1	2004-06-17	Newcomer	
	4	20060106483	A1	2006-05-18	Behan et al.	
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	6	20050154431	A1	2005-07-14	Quistgaard et al.	
	7	20110178627	A1	2011-07-21	Wechter et al.	

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	2	International Search Report and Written Opinion of the International Searching Authority for International Application No. PCT/US2006/39215, June 1, 2007.	
	3	Search Report issued by the European Patent Office for European Application No. 12744452.9 dated July 24, 2015.	
	4	Assembly Guidance System Inc.'s LASERGUIDE brochure, publication date unknown.	
	5	Assembly Guidance System Inc.'s LASERGUIDE Productivity and Flexibility brochure, publication date unknown.	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	
	First Named Inventor	Paul Ryznar et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	RYZ01 P-101B

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See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl T. Ondersma/	Date (YYYY-MM-DD)	2017-05-19
Name/Print	Karl T. Ondersma	Registration Number	55894

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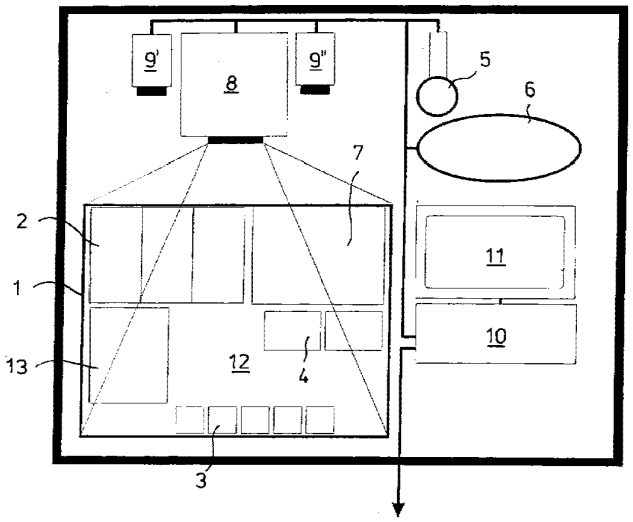
(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:
DE 37 17 938 A1

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

Prüfungsantrag gemäß § 44 PatG ist gestellt.

(54) Bezeichnung: **Verfahren und Vorrichtung zur Unterstützung der an einem Werkstattarbeitsplatz auszuführenden Tätigkeiten**

(57) Zusammenfassung: Verfahren und Vorrichtung zur Unterstützung der an einem Werkstattarbeitsplatz auszuführenden Tätigkeiten, wobei der Werkstattarbeitsplatz mindestens einen Arbeitstisch oder Werkstückträger, Werzeuge und/oder Bauteile umfasst. Hierzu wird der Arbeitsplatz so ausgebildet, dass oberhalb des Arbeitsplatzes eine Bilderzeugungseinrichtung angeordnet wird, die von einem Computer gesteuert starre Bilder der einzelnen Arbeitsfolgen darstellt. Gleichzeitig werden die dazu benötigten Werkzeuge und Bauteile beleuchtet. Mit einer zusätzlich oberhalb angeordneten Kamera kann der Arbeitsplatz weiter hinsichtlich Qualitätskontrolle benutzt werden. Das Verfahren und der Arbeitsplatz gestatten eine Vielzahl von Funktionen zur Erleichterung der Tätigkeiten, Erfassung der Betriebsdaten und Verbesserung der Qualität.



Beschreibung

[0001] Die vorliegende Erfindung betrifft ein Verfahren zur Unterstützung der an einem Werkstattarbeitsplatz auszuführenden Tätigkeiten, wobei der Werkstattarbeitsplatz mindestens eine Arbeitsfläche oder Werkstückträger, Werkzeuge und/oder Bauteile umfasst, sowie eine Vorrichtung zum Durchführen des Verfahrens.

Stand der Technik

[0002] Derartige Werkstattarbeitsplätze sind bekannt und allgemein üblich. Diese Werkstattarbeitsplätze weisen häufig als Arbeitsfläche einen Arbeitstisch oder eine sonstige zur Ablage von Bauteilen und Arbeitsmaterialien auf. An diesen Werkstattarbeitsplätzen werden Arbeiten, wie beispielsweise Prüfen, Montieren und auch Schulungen vorgenommen. Üblicherweise sind im Bereich der Arbeitsplätze griffbereit Werkzeuge und Kleinmaterialien, die beispielsweise in sogenannten Greifboxen untergebracht sind, vorhanden. Die Anweisungen für die Ausführenden werden der Arbeitsperson über Zeichnungen oder andere druckschriftliche Wiedergabemedien, die ebenfalls an dem Werkstattarbeitsplatz untergebracht werden können, mitgeteilt.

Aufgabenstellung

[0003] Der vorliegenden Erfindung liegt die Aufgabe zugrunde ein Verfahren und eine Vorrichtung vorzuschlagen, die die Möglichkeiten der Anweisung an die Arbeitsperson anders als bisher erlaubt und darüber hinaus zusätzliche Qualitätskontrollen, Datenerfassung und andere Anwendungserweiterungen ermöglicht.

[0004] Diese Aufgabe wird erfindungsgemäß durch ein Verfahren mit den Merkmalen des Verfahrensanspruchs sowie durch eine Vorrichtung mit den Merkmalen des Vorrichtungsanspruchs gelöst. Weitere vorteilhafte Ausgestaltungen sind den jeweiligen diesbezüglich rückbezogenen Unteransprüchen zu entnehmen.

[0005] Gemäß dem Verfahren werden die einzelnen Arbeitsschritte, die in einem Speicher abgelegt sind, von einer zentralen Steuereinheit ausgelesen und über eine Bilderzeugungseinrichtung auf der Arbeitsfläche oder in der Nähe der Arbeitsfläche abgebildet. Damit sieht die Arbeitsperson die einzelnen Arbeitsschritte als starre Bilder und kann entsprechend dem jeweiligen Arbeitsschritt die Montage oder Prüfung vornehmen. Das Verfahren ist auch geeignet, um als Lernprogramm zum Schulen von neuen Mitarbeitern angewendet zu werden. Die Abfolge der einzelnen Bilder wird von der Arbeitsperson selbst über geeignete Auslösemittel wie beispielsweise Tastaturen oder anderen Signalen (beispielsweise Geräusche) ausgelöst.

[0006] Gemäß einer weiterer Ausbildung des Verfahrens werden die für die Tätigkeit erforderlichen Werkzeuge und/oder Bauteile beleuchtet. Damit wird die Arbeitsweise weiter vereinfacht, da gleichzeitig mit der Abbildung des Arbeitsschrittes an einer ganz bestimmten Stelle auf der Arbeitsfläche oder in der Nähe der Arbeitsfläche die einzelnen dazu notwendigen Werkzeuge oder auch Greifboxen, in denen die anzubringenden Teile untergebracht sind, beleuchtet werden.

[0007] Gemäß einer anderen Ausbildung kann gemäß dem Verfahren die genaue Position des zu montierenden Teils an beispielsweise einem bereits vorhandenen größeren Teil angezeigt werden.

[0008] In einer weiteren Ausbildung des Verfahrens werden Organisationsdaten, wie beispielsweise Sollstückzahlen, Zeitvorgabe, Auftragsnummer usw. der Arbeitsperson als Display-Funktion zur Verfügung gestellt. Des Weiteren können vorteilhafterweise auch die Betriebsdaten (beispielsweise Bearbeiter, tatsächlich benötigte Zeit, Uhrzeit der Fertigung) durch Eingabe entsprechender Werte bzw. Eingabe der Startzeit erfasst werden.

[0009] In einer weiteren Ausbildung des Verfahrens werden die an oder auf der Arbeitsfläche angeordneten Bedienelemente durch die Steuereinheit je nach Bedarf mit der entsprechenden Funktion belegt und in der Funktion entsprechend gekennzeichnet. Dadurch ist es möglich, nur mit ganz wenigen Bedienelementen auszukommen, da bei einer Anordnung von einer Vielzahl von Bedienelementen selten alle bei einem Auftrag benötigt werden. Es ist daher möglich auftragsbezogen und auch entsprechend der einzelnen Arbeitsschritte die Bedienelemente unterschiedlich zu belegen, so dass dadurch nur ganz wenig Bedienelemente notwendig sind. Gleichzeitig kann das jeweilige zu betätigende Bedienelement, vergleichbar mit den Greifboxen oder den Werkzeugen angeleuchtet werden. Auch die Kennzeichnung seiner augenblicklichen Funktion kann damit erfolgen. So kann beispielsweise ein Taster der im einen Fall für das Ein- und Ausschalten einer Druckluftein-heit verwendet wird, im nächsten Fall für das Ein- und Ausschalten einer Messstation verwendet werden. Vorzugsweise können die einzelnen Tastelemente auch als ein Tastbildschirm ausgebildet sein, dessen Funktionen entsprechend belegt und gekennzeichnet sind.

[0010] Um das Verfahren hinsichtlich seiner Anwendbarkeit noch mehr zu erweitern, wird gemäß einer weiteren vorteilhaften Ausgestaltung mittels einer oberhalb der Arbeitsfläche angeordneten Bilderfassungseinrichtung zumindest die Arbeitsfläche mit allen für den Arbeitsvorgang benötigten Werkzeugen

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und/oder Bauteilen optisch erfasst und in der zentralen Steuereinheit ausgewertet. Dadurch kann beispielsweise eine Qualitätskontrolle durch Verfolgung der Bewegungen der Teile bzw. der Hände erfolgen. Wird beispielsweise ein Teil vergessen, so kann damit über die zentrale Steuereinheit ein Hinweis ausgegeben werden. Dieses Prinzip ermöglicht auch die Anwendung von virtuellen Tastern, wobei hierzu ggf. noch eine zweite Bilderfassungseinrichtung notwendig sein kann, die von der Seite die Handbewegungen zumindest in diesem Bereich erfasst.

[0011] Des Weiteren können die auszuübenden Tätigkeiten gemäß dem erfindungsgemäßen Verfahren in einem Videoclip abgebildet werden, wobei die Töne über eine zusätzliche Geräuschausgabe ausgegeben werden. Dies erleichtert zum Beispiel das Erlernen neuer Tätigkeiten. Als Erweiterung kann eine Live-Viedeokamera das aktuelle Bild an einen Trainerplatz zur Kontrolle senden. Als eine weitere Ausgestaltung kann ein im manuellen Arbeitsbereich befindliches automatisches System die Tätigkeit unterstützen. Dabei wird der aktuelle Sicherheitszustand, der ein Eingreifen der Arbeitsperson zu bestimmten Zeiten verbietet, durch eine entsprechende Beleuchtung, beispielsweise in einer bestimmten Farbe, visualisiert. Es wird dann das automatische System entsprechend angestrahlt.

[0012] Die erfindungsgemäße Vorrichtung zum Durchführen des Verfahrens weist eine Bilderzeugungseinrichtung auf, die mindestens ein Bild auf oder angrenzend an die Oberfläche des Arbeitstisches oder einer Projektionsfläche, auch in Rückprojektion (von unten), abbildet. Des Weiteren ist eine zentrale Steuereinheit, die mit der Bilderzeugungseinrichtung verbunden ist und über die Bildverarbeitungseinrichtung in einem Speicher abgelegte Bilder ausgibt, vorgesehen. An oder auf der Arbeitsfläche ist eine Tastatur zur Eingabe von Daten und/oder Ein-/Ausschaltvorgänge vorgesehen. Hierbei kann es sich einmal um eine numerische Tastatur und entsprechende zusätzliche Taster oder Einschalter für die Schaltvorgänge handeln. Bei der Vorrichtung projiziert die Bilderzeugungseinheit sowohl die einzelnen auszuführenden Arbeitsschritte für den Bediener sichtbar und auch die dazu erforderlichen Werkzeuge und/oder Bauteile.

[0013] Gemäß einer weiteren Ausbildung der Vorrichtung ist oberhalb der Arbeitsfläche eine Bilderfassungseinheit, beispielsweise eine Videokamera oder sonstige geeignete, dem Fachmann bekannte Einrichtung vorgesehen, die ebenfalls mit der zentralen Steuereinheit verbunden ist.

Ausführungsbeispiel

[0014] Nachfolgend wird die Erfindung anhand eines Ausführungsbeispiels in Verbindung mit den begleitenden Zeichnungen näher erläutert. Es stellen dar:

[0015] **Fig.** 1 ein schematisches Blockschaltbild für den Werkstattarbeitsplatz und

[0016] **Fig.** 2 eine perspektivische Ansicht eines anderen Werkstattarbeitsplatzes.

[0017] Das Blockschaltbild gemäß **Fig.** 1 zeigt schematisch die Oberseite beispielsweise eines Arbeitstisches **1** an dem zur Materialbereitstellung Greifboxen **2** zur Aufnahme von Kleinteilen und Werkzeug **3** angeordnet sind. Auf der rechten Seite des Arbeitstisches befindet sich eine Tastatur **4**, die eine Zifferntastatur sowie beispielsweise Taster für Schaltvorgänge umfassen kann. Des weiteren befindet sich ein Mikrofon **5**, ein Lautsprecher **6**, sowie eine Fläche **7** für die Abbildung von starren Bildern der Arbeitsfolge oder für ein Video im Bereich der Arbeitsfläche **13**. Oberhalb des Arbeitstisches **1** befindet sich die Bilderzeugungseinrichtung **8**, beispielsweise ein Beamer, sowie zwei Bilderfassungseinrichtung **9'**, **9"** in Form einer geeigneten Kamera. Beide sind mit einer zentralen Steuereinheit **10** verbunden. Der Steuereinheit **10** ist ein Speicher **11** zugeordnet. Die zentrale Steuereinheit **10** und der Speicher **11** können beispielsweise Teil eines üblichen Computers mit Tastatur und Monitor sein. Die zentrale Steuereinheit **10** ist außerdem über eine Leitung **12** mit einem Netzwerk verbindbar, beispielsweise um aktuelle Daten abfragen und einlesen zu können. In der Figur ist außerdem mit der Bezugsziffer **13** eine automatische Einrichtung angedeutet, in der einzelne Arbeitsschritte vollautomatisch durchgeführt werden.

[0018] Es kann sich dabei auch um einen Roboter handeln. Solange die Einrichtung **13** tätig ist, kann sie mit einer besonderen Farbe durch die Bilderzeugungseinrichtung beleuchtet werden, damit die Arbeitsperson dies erkennt. Ein Eingreifen in den Arbeitsbereich führt automatisch zu einen Anhalten der Einrichtung **13**.

[0019] Seitlich des Arbeitstisches **1** kann eine zusätzliche weitere Bilderfassungseinheit (nicht dargestellt) angeordnet sein, so dass dadurch die Taster **4** durch virtuelle Taster ersetzbar sind. Statt dessen ist es auch möglich, eine tastsensitive Fläche wie beispielsweise Tastbildschirm, zu verwenden.

[0020] **Fig.** 2 zeigt schematisch einen Arbeitsplatz mit einem Arbeitstisch **1** mit den im Halbkreis angeordneten Greifboxen **2** und einer oberhalb angeordneten Bilderzeugungseinrichtung **8**, hier in Form einer Umlenkeinrichtung. Auf und an diesem Tisch sind dann die in der **Fig.** 1 dargestellten Elemente entsprechend **Fig.** 2 anzuordnen.

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Patentansprüche

1. Verfahren zur Unterstützung der an einem Werkstattarbeitsplatz auszuführenden Tätigkeiten wobei der Werkstattarbeitsplatz mindestens eine Arbeitsfläche, Werkzeuge und/oder Bauteile umfasst, **dadurch gekennzeichnet**, dass einzelne Arbeitsschritte, die in einem Speicher (**11**) abgelegt sind, von einer zentralen Steuereinheit (**10**) ausgelesen und über eine Bilderzeugungseinrichtung (**8**) auf der Arbeitsfläche (**12**) oder in der Nähe der Arbeitsfläche abgebildet werden.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die für die Tätigkeit erforderlichen Werkzeuge (**3**) und/oder Bauteile (**2**) beleuchtet werden.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass die genaue Position eines zu montierenden Teils angezeigt wird.

4. Verfahren nach einem der vorangegangenen Ansprüche, dadurch gekennzeichnet, dass Organisationsdaten angezeigt werden.

5. Verfahren nach einem der vorangegangenen Ansprüche, dadurch gekennzeichnet, dass die Betriebsdaten erfasst werden.

6. Verfahren nach einem der vorangegangenen Ansprüche, dadurch gekennzeichnet, dass an oder auf der Arbeitsfläche angeordnete Bedienelemente (**4**, **5**) durch die Steuereinheit (**10**) je nach Bedarf mit der entsprechenden Funktion belegt und der Funktion entsprechend gekennzeichnet werden.

7. Verfahren nach Anspruch 6, dadurch gekennzeichnet, dass als Bedienelemente ein Tastbildschirm verwendet wird, dessen Funktionen entsprechend belegt und gekennzeichnet werden.

8. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass mittels einer oberhalb der Arbeitsfläche (**12**) angeordneten Bilderfassungseinrichtung (**9**) die Arbeitsfläche mit allen für den Arbeitsvorgang benötigten Werkzeuge (**3**) und/oder Bauteile (**2**) optisch erfasst und in der zentralen Steuereinheit (**10**) ausgewertet werden.

9. Verfahren nach Anspruch 8 und 6, dadurch gekennzeichnet, dass die Bedienelemente (**5**) virtuell abgebildet werden und die Betätigung der Bedienelemente mittels einer zweiten Bilderfassungseinrichtung festgestellt wird.

10. Verfahren nach Anspruch 8 und 6, dadurch gekennzeichnet, dass die Bedienelemente (**5**) virtuell abgebildet werden und die Betätigung der Bedienelemente mittels einer tastsensitiven Fläche festgestellt wird.

11. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass für das Anlernen der auszuübenden Tätigkeit ein Videoclip abgebildet und der Ton über eine zusätzliche Geräuschausgabe (**6**) ausgegeben wird.

12. Werkstattarbeitsplatz mit einer Arbeitsfläche, Werkzeugen und/oder Bauteilen zur Durchführung des Verfahrens nach einem der Ansprüche 1–7, gekennzeichnet durch
eine Bilderzeugungseinrichtung (**8**) zur Projektion eines Abbildes auf eine Projektionsfläche mittels der mindestens ein Bild auf- oder angrenzend an die Arbeitsfläche (**12**) abbildbar ist;
eine zentrale Steuereinheit (**10**), die mit der Bilderzeugungseinrichtung (**8**) verbunden ist und über die Bilderzeugungseinrichtung (**8**) in einem Speicher abgelegte Bilder ausgibt;
einen Arbeitstisch mit einer Tastatur (**4**) zur Eingabe von Daten und/oder Ein-/Ausschaltvorgängen;
wobei die Bilderzeugungseinrichtung (**8**) sowohl die einzelnen auszuführenden Arbeitsschritte für den Bediener sichtbar projiziert als auch die dazu erforderlichen Werkzeuge (**3**) und/oder Bauteile (**2**) beleuchtet.

13. Werkstattarbeitsplatz nach Anspruch 11, dadurch gekennzeichnet, dass oberhalb der Arbeitsfläche (**12**) eine Bilderfassungseinrichtung (**9**) angeordnet ist, die ebenfalls mit der zentralen Steuereinheit (**10**) verbunden ist.

Es folgen 2 Blatt Zeichnungen

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Anhängende Zeichnungen

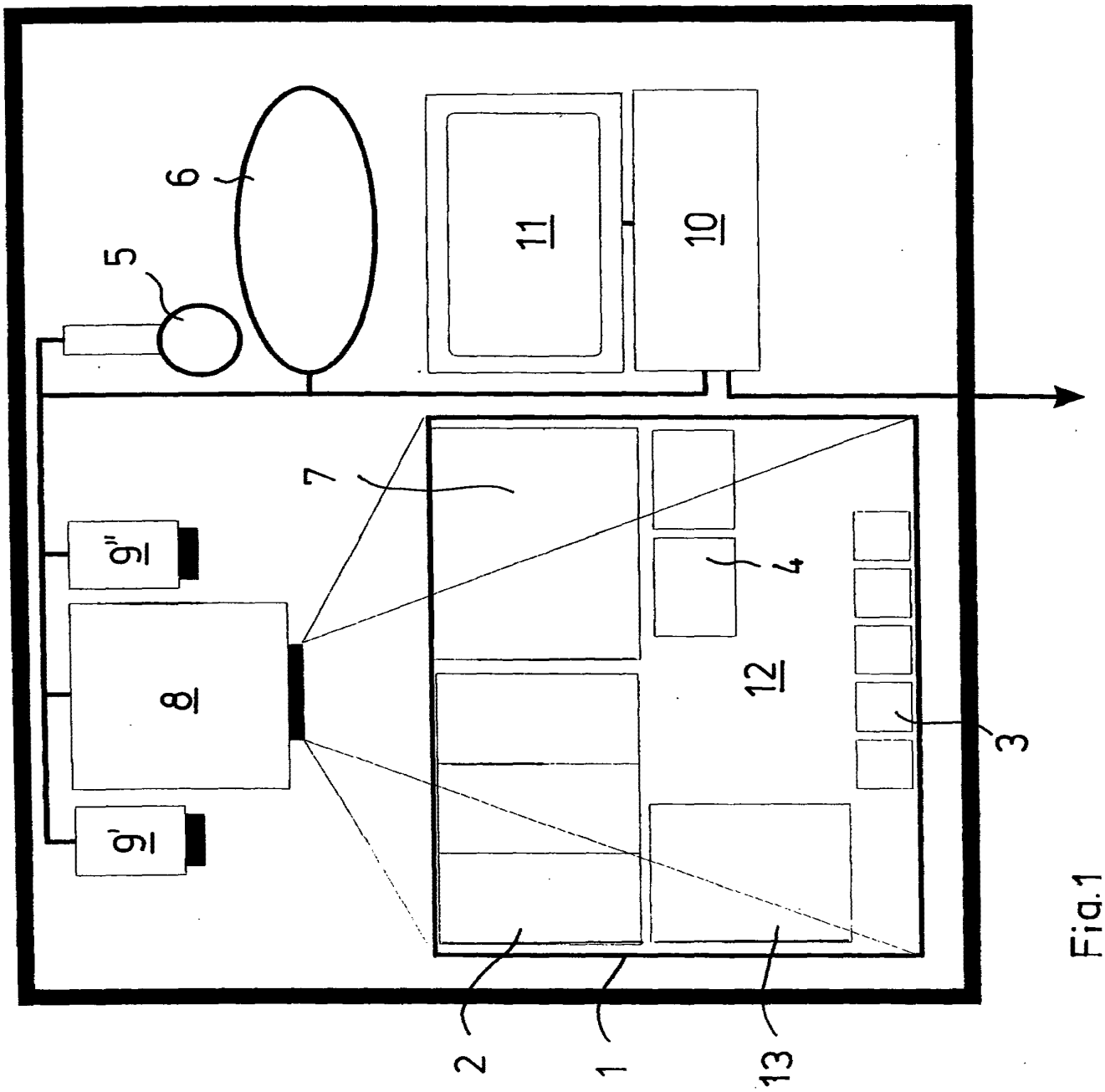


Fig.1

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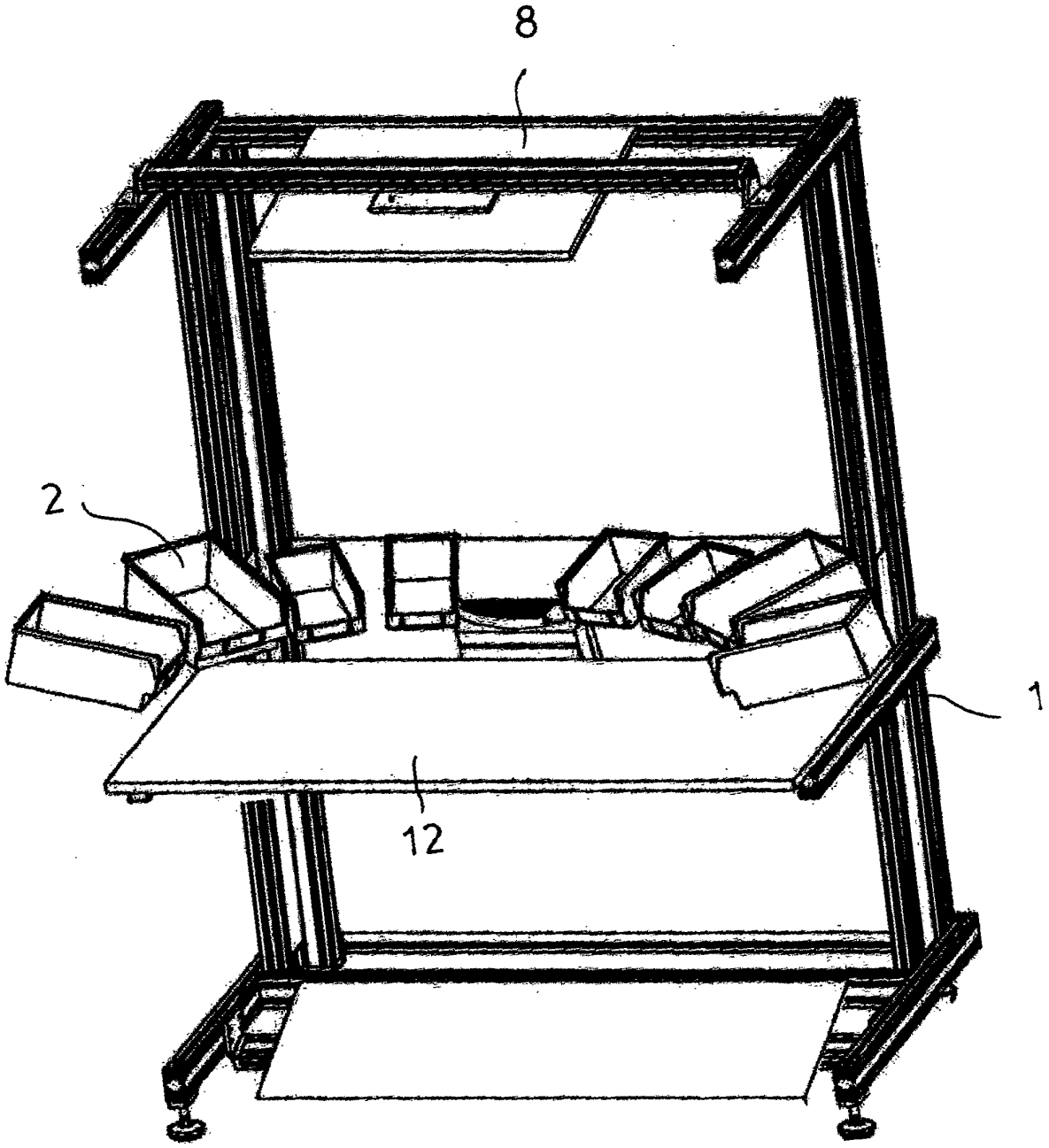


Fig. 2

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Espacenet

Bibliographic data: DE10320557 (A1) — 2004-12-09

Workstation for carrying out manufacturing or other work processes has a projection unit with a memory and a control unit for output of operating, training and reference information to the work surface so that it can be viewed

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Classification: - international: ***B23P21/00; B23Q17/24; H05K13/00;*** (IPC1-7): B25H1/02
- cooperative: **B23P21/00**; **B23Q17/2404**; **H05K13/0053**

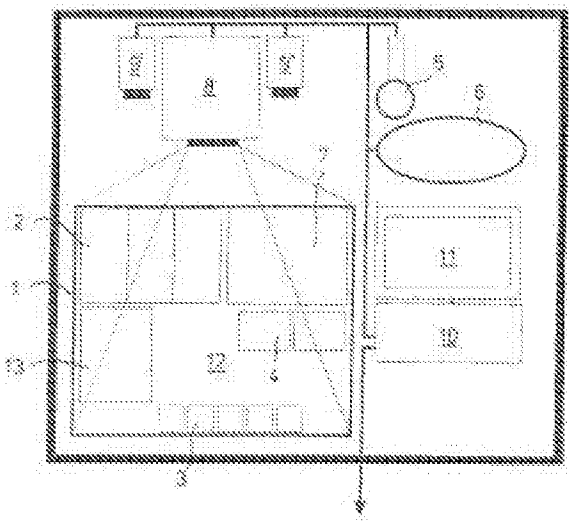
Application number: DE2003120557 20030507

Priority number (s): DE2003120557 20030507

Also published as: DE10320557 (B4)

Abstract of DE10320557 (A1)

Method for supporting the activities to be carried out at a workstation that comprises a work surface, tools and or other components. According to the method individual work steps that are stored in a memory (11) are read out from a central control unit (10) and projected using an image generating unit (8) on the work surface (12) and or its adjoining surfaces. The invention also relates to a corresponding workstation.



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DESCRIPTION DE10320557

The present invention relates to a method for Unterstützungder at a workshop workplace activities to be performed, the workshop workplace least a work surface or workpiece carriers, tools and / or Bauteileumfasst, and an apparatus for performing the method.

Such workshop workplaces are known and common practice.

This workshop workplaces frequently have as a work surface a work table or in another for storing components and materials.

At this workshop workplaces work, such as checking, installing are made andalso training.

Typically, in the area of jobs to hand tools and small materials that are housed in so-called example gripping boxes available.

The instructions for the performers are working person on drawings or other pressure-written reproduction media, which can also be accommodated at demWerkstattarbeitsplatz informed.

The present invention has for its object a Verfahrenund propose a device which to work Person Unlike allowed the possibilities of the statement date and will provide additional quality controls, Datenerfassungund allows other application extensions.

This object is inventively achieved by a method having the characteristic end method claim and by a device with the features of apparatus claim resolved.

Further advantageous embodiments are given in appended dependent claims in this regard the relevant.

According to the method the individual working steps which are stored in a memory, read out by a central control unit and an image forming means on the work surface or in the vicinity of the Arbeitsflächeabgebildet.

Thus the worker sees the individual steps as rigid images and can according to the respective step, the assembly or test making.

The method is also suitable to be used as a learning program for schools vonneuen employees.

The sequence of the individual images is Vonder working person himself through suitable triggering means such as keyboard or other signals triggered (eg noise).

According to a further embodiment of the process required for dieTätigkeit tools and / or components are illuminated.

Thus dieArbeitsweise is further simplified since the same time, be illuminated with the image of Arbeitsschrittesan a particular point on the work surface or near the Arbeitsflächedie individual necessary molds or gripping boxes in which the mounted parts are housed.

According to another embodiment, the exact position of the part to be mounted on can be displayed, for example, an existing large part according to the method.

In a further embodiment of the method organizational data, such as target quantities, timing, order number, etc. of the working staff display function are provided.

Furthermore, advantageously, the operating data (eg processor, actually required time Uhrzeitder production) by entering corresponding values or

Be detected entering the starting time.

In a further embodiment of the method which are arranged on or aufder workspace controls to be used by the control unit depending on Bedarfmit the corresponding function and are marked accordingly in the function.

This makes it possible to make do with very few controls because beieiner arrangement of a plurality of control elements are rarely all at a Auftragbenötigt.

Therefore, it is possible to order and also according dereinzelnen steps to validate the controls differently, so that this very little controls are necessary.

At the same time, the jeweiligezu operable control element, are similar to the gripping boxes or tools illuminated.

Also marking its instantaneous function can thus be carried out.

For example, a button that is used in a case for the switching on and off of a compressed air unit can be used in the next case for dasEin- and off a station.

Preferably dieeinzelnen sensing elements can also be designed as a touch screen, whose function According occupied and marked.

To extend the process in terms of its applicability even more, according to a further advantageous embodiment, by means of an above derArbeitsfläche arranged image capture device at least the Arbeitsflächemit all Werkzeugenund / or components required for the operation optically detected and evaluated in the central control unit.

This can for example be a quality control by tracking the movements of the hands or changed parts.

For example, if a part forgotten, can thus on the central control unit a notice will be issued.

This principle made light without limitation of virtual buttons, for which purpose, if necessary, may be a second image capture device necessary nor that. From the side, the hand movements, at least in this region Captures

Furthermore, the activities to be exercised in accordance with the method according to the invention can be displayed in a video clip, in which the tones are output via an additional sound output.

This facilitates, for example, new learning activities.

As an extension, a live Viedeokamera send the current picture to a coach's seat to control.

As a further refinement can support the activities of a work in manually workspace automatic system.

In this case, the current security state, which prohibits to determine intervention times the worker, by selecting the appropriate lighting, for example in a particular color, visualized.

It is accordingly illuminated then the automated system.

The inventive device on for performing the method, an image forming apparatus which reproduces at least one picture on the surface or angrenzendan the worktable or a projection, even in rear projection (from the bottom).

Furthermore, a central control unit, which is connected to derBilderzeugungseinrichtung and outputs via the Bildverarbeitungseinrichtungin a memory stored images, are provided.

Provided at or on the Arbeitsflächeist a keyboard for inputting data and / or switch on / off.

This may even be a numeric keypad and appropriate additional switch or power switch for switching operations.

In the apparatus projiziertdie imaging unit both the individual steps executed forthe operator visible and also the necessary tools and / or components.

According to a further embodiment of the device, for example a video camera or other suitable means known in the art is above the working surface of an imaging unit, is provided which is also connected to the central control unit is connected.

The invention by way of example inVerbindung with the accompanying drawings will be explained in more detail.

It represent:

1An schematic block diagram forthe workshop workplace and

2 shows a perspective view of a different workshop workplace.

The block diagram gemäß1zeigt schematischdie top example of the Arbeitstisches1an to MaterialbereitstellungGreifboxen2zur recording small parts and Werkzeug3angeordnetsind.

On the right side of the worktable is a Tastatur4 which can be a numeric keypad as well as buttons for switching operations for Embrace.

Furthermore, there is a Mikrofon5, a Lautsprecher6, and a Fläche7für the mapping of rigid images derArbeitsfolge or a video in the Arbeitsfläche13.

Oberhalbdes Arbeitstisches1befindet the Bilderzeugungseinrichtung8, for example, a projector, and two Bilderfassungseinrichtung9 ', 9"in form a suitable camera.

Both are equipped with a central Steuereinheit10verbunden.

The Steuereinheit10istein Speicher11zugeordnet.

The central Steuereinheit10undder Speicher11können example, be part of a standard computer monitor and mitTastatur.

To a network connectable, query the central Steuereinheit10ist also has a Leitung12mit example, current data and read.

In the figure is also equipped with the automatic device Bezugsziffer13eine indicated, are carried out in the individual work steps automatically.

They may be also be a robot.

As long as the Einrichtung13tätig is, it can be through the imaging device illuminates with a special color, so that the working person recognizes this.

An intervention in the workspace automatically lead to a stoppage of Einrichtung13.

Laterally of Arbeitstisches1kann an additional further imaging unit (not shown) may be arranged so that by the Taster4durch virtual buttons are replaceable.

Instead, it is also possible to use a touch-sensitive surface such as touch screen.

2shows schematically a Arbeitsplatzmit a Arbeitstisch1mit the arranged in a semicircle above a Greifboxen2und arranged Bilderzeugungseinrichtung8, here in the form of a deflection.

On and around this table in the der1dargestellten elements are then entsprechend2anzuordnen.

Europäisches Patentamt
European Patent Office
Office européen des brevets

Patent Translate
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Notice

This translation is machine-generated. It cannot be guaranteed that it is intelligible, accurate, complete, reliable or fit for specific purposes. Critical decisions, such as commercially relevant or financial decisions, should not be based on machine-translation output.

CLAIMS DE10320557

A method of supporting auszuführendenTätigkeiten at a workshop workplace where the workshop workplace at least a work surface, Werkzeugeund / or components includes, characterized in that individual work steps (11) are stored in a memory of a central control unit (10) is read out and an image forming apparatus (8) are mapped aufder working surface (12) or in the vicinity of the working surface.

A method according to claim 1, characterized in that the necessary dieTätigkeit tools (3) and / or components (2) are illuminated.

The method of claim 1 or 2, characterized in that diegenaue position of a part to be mounted is displayed.

Method according to one of the preceding claims, characterized in that organization information is displayed.

Method according to one of the preceding claims, characterized in that the operating data are detected.

Method according to one of the preceding claims, characterized in that at or on the working surface control elements (4,5) by the control unit (10) according to need is assigned the function corresponding to the function and are marked accordingly.

A method according to claim 6, characterized in that touch screen is used as Bedienelementeein whose functions are assigned and marked accordingly.

A method according to claim 1, characterized in that arranged by means of a top of the working surface (12) image capturing means (9) evaluates the work surface with all required for the operation tools (3) and / or components (2) is optically detected and in the central control unit (10) become.

The method of claim 8 and 6, characterized in that the control elements (5) are represented virtually and operation of the controls is determined means a second image capture device.

The method of claim 8 and 6, characterized in that thieves operating elements (5) are represented virtually and operation of the controls by means of a touch-sensitive surface is detected.

The method of claim 1, characterized in that displayed a video clip for the Anlernender exercised activities and the sound from an additional sound output (6) is issued.

Workshop workstation with a work surface, tools and / or devices for performing the method according to one of claims 1-7, characterized by an imaging device (8) for projecting an image onto a projection surface by means of at least up an image or adjacent to the working surface (12) is imaged; a central control unit (10) which is connected to the image generating means (8) and is output from the imaging means (8) ina memory stored images; a work table with a keyboard (4) for inputting data and / oderEin- / off operations; said image forming means (8) both the individual auszuführendenArbeitsschritte for the operator as well as the visible projected to necessary tools (3) and / or components (2) illuminates.

Workshop workstation according to claim 11, characterized in that above the working surface (12) an image capture device (9) is arranged, which verbundenist also connected to the central control unit (10).

Here the 2 leaf drawings

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
KARL T. ONDERSMA

GARDNER, LINN, BURKHART AND FLORY, LLP 2851
CHARLEVOIX DRIVE SE, SUITE 207 P.O. BOX 888695
GRAND RAPIDS MI 49588-8695 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**02 JULY 2012 (02.07.2012)**
Applicant's or agent's file reference RYZ01FP101WO	**FOR FURTHER ACTION** See paragraph 2 below Reply Due December 11, 2012

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2012/024730	**10 FEBRUARY 2012 (10.02.2012)**	11 FEBRUARY 2011 (11.02.2011)

International Patent Classification (IPC) or both national classification and IPC

G01C 15/02(2006.01)i

Applicant

RYZNAR PAUL et al

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	14 JUNE 2012 (14.06.2012)	PARK, TAE WOOK Telephone No.82-42-481-8420

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2012/024730

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Amazon Ex. 1002.0083

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2012/024730

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-29	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	1-29	YES
	Claims	NONE	NO
Industrial applicability (IA)	Claims	1-29	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2006-0059699 A1 (NORMAN L. KRANTZ) 23 March 2006
D2: US 2004-0111901 A1 (RONALD E. NEWCOMER) 17 June 2004
D3: US 2006-0185181 A1 (CHARLES LONG et al.) 24 August 2006

1. Novelty and Inventive Step
The subject matter of claim 1 differs from these prior art documents in that it includes a guide system controller including a plurality of addressed display features; and it selects an addressed display feature based on said input signal; and it projects a visual indicator corresponding to said selected addressed display feature onto a physical object.

And the subject matter of claim 1 is not obvious to a person skilled in the art by the documents, taken alone or in combination.

Therefore, claim 1 meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

Claims 2-14 are dependent on claim 1. Therefore they meet the requirements of PCT Article 33(2) and (3).

Claims 15, 24 and 29 relate to guide systems according to claim 1. Claims 15, 24 and 29 are considered to be novel and to involve an inventive step under PCT Article 33(2)-(3), because the subject matter of claim 1 is considered to be novel and to involve an inventive step.

Claims 16-23 and 25-28 are dependent on claim 15 or 24. Therefore they meet the requirements of PCT Article 33(2) and (3).

2. Industrial Applicability
Claims 1-29 are industrially applicable under PCT Article 33(4).

Amazon Ex. 1002.0084

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference RYZ01FP100PC	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US06/39215	International filing date (*day/month/year*) 06 October 2006 (06.10.2006)	(Earliest) Priority Date (*day/month/year*) 07 October 2005 (07.10.2005)
Applicant OPS SOLUTIONS LLC		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the Report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed.
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   ☐ the text is approved as submitted by the applicant.
   ☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 1
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figures is to be published with the abstract.

Amazon Ex. 1002.0085

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US06/39215

Box IV TEXT OF THE ABSTRACT (Continuation of Item 5 of the first sheet)

NEW ABSTRACT:
An operational guide system (10) adapted to provide visual indicators to an individual to guide sequential actions includes at least one sensor apparatus (26), a controller (20), and at least one directional light device (22, 24). The sensor apparatus (26) is operable to detect operation information and generate an output indicative of the sensed operation information. The controller (20) receives at least a first input signal indicative of the operation information and selectively provides at least one command signal in response to the first input signal. The at least one directional light device (22, 24) being selectively operable to project and target at least one indicating light in response to the at least one command signal from the controller (20).

Amazon Ex. 1002.0086

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US06/39215

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **G01M 19/00**(2006.01);**B23P 17/04**(2006.01),**19/00**(2006.01),**21/00**(2006.01);**G06F 17/00**(2006.01)
G06F 19/00(2006.01)

USPC: 29/407.1,407.04,592,700,703;700/95,115
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 29/407.1,407.04,592,700,703;700/95,115

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IEEE/Xplore

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPAT; US-PGPUB; USOCR; EPO, JPO, DERWENT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,910,894 A (PRYOR) 8 June 1999 (08.06.1999), entire document.	1-23
A	US 5,119,536 A (LEITZ et al.) 9 June 1992 (09.06.1992), entire document.	1-23
A	US 5,430,662 A (AHONEN) 4 July 1995 (04.07.1995), entire document.	1-23
A	US 5,506,641 A (DORSEY-PALMATEER) 9 April 1996 (09.04.1996), entire document.	1-23
A	US 4,469,553 A (WHITEHEAD) 4 September 1984 (04.09.1984), entire document.	1-23
A	US 4,222,036 A (TROUKENS) 9 September 1980 (09.09.1980), entire document.	1-23
A	US 4,102,568 A (MIYAGI) 25 July 1978 (25.07.1978), entire document.	1-23

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May 2007 (15.05.2007)	01 JUN 2007
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201	Authorized officer David N. Spector Telephone No. (571) 272-2338

Form PCT/ISA/210 (second sheet) (April 2005)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
VAN DYKE, GARDNER, LINN AND BURKHART, LLP AND ITS
2851 CHARLEVOIX DRIVE S.E., SUITE 207
P.O. BOX 888695
GRAND RAPIDS, MI 49588-8695

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	01 JUN 2007
Applicant's or agent's file reference RYZ01FP100PC	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US06/39215	06 October 2006 (06.10.2006)	07 October 2005 (07.10.2005)

International Patent Classification (IPC) or both national classification and IPC

IPC: Please See Continuation Sheet
USPC: 29/407.1,407.04,592,700,703;700/95,115

Reply Due September 1, 2007

Applicant

OPS SOLUTIONS LLC

1. This opinion contains indications relating to the following items:

- [X] Box No. I — Basis of the opinion
- [ ] Box No. II — Priority
- [ ] Box No. III — Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV — Lack of unity of invention
- [X] Box No. V — Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI — Certain documents cited
- [ ] Box No. VII — Certain defects in the international application
- [ ] Box No. VIII — Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(*b*) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/ US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201	15 May 2007 (15.05.2007)	David N. Spector Telephone No. (571) 272-2338

Form PCT/ISA/237 (cover sheet) (April 2005)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US06/39215

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

☒ the international application in the language in which it was filed

☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

a. type of material

☐ a sequence listing

☐ table(s) related to the sequence listing

b. format of material

☐ on paper

☐ in electronic form

c. time of filing/furnishing

☐ contained in the international application as filed.

☐ filed together with the international application in electronic form.

☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table(s) relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Amazon Ex. 1002.0089

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US06/39215

Box No. V Reasoned statement under Rule 43 *bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims 1-23	YES
	Claims NONE	NO
Inventive step (IS)	Claims 1-23	YES
	Claims NONE	NO
Industrial applicability (IA)	Claims 1-23	YES
	Claims NONE	NO

2. Citations and explanations:

Claims 1-23 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest an operational guide system or assembly guide system adapted to provide visual indicators to an individual to guide sequential actions at a work location; comprising at least one sensor apparatus operable to detect operation information and generate an output indicative of the operation information, a controller receiving at least a first input signal indicative of the operation information and selectively providing at least one command signal in response to the first input signal, and at least one directional light device selectively operable to project and target at least one indicating light in response to the at least one command signal from the control module.

Claims 1-23 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry to facilitate product assembly and other operational tasks requiring the execution of a series of sequential steps.

Amazon Ex. 1002.0090

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US06/39215

Supplemental Box
In case the space in any of the preceding boxes is not sufficient.

Continuation of IPC:
G01M 19/00(2006.01);**B23P 17/04**(2006.01),**19/00**(2006.01),**21/00**(2006.01);**G06F 17/00G01M 19/00;B23P 17/04**(2006.01),**19/00**(2006.01),**21/00**(2006.01);**G06F 17/00**
(2006.01)
G06F 19/00
(2006.01)

Amazon Ex. 1002.0091

The examination is being carried out on the **following application documents**

Description, Pages

1-31 as published

Claims, Numbers

1-15 filed with entry into the regional phase before the EPO

Drawings, Sheets

1-14 as published

1 Reference is made to the following documents:

D1 US 7 515 981 B2 (RYZNAR PAUL [US] ET AL) 7 April 2009 (2009-04-07)

D2 US 2006/106483 A1 (BEHAN WILLIAM M [US] ET AL) 18 May 2006 (2006-05-18)

D3 US 2007/180674 A1 (MORDEN JARRAD V [CA] ET AL) 9 August 2007 (2007-08-09)

D4 DE 103 20 557 A1 (MARTIN MECHANIC FRIEDRICH MART [DE]) 9 December 2004 (2004-12-09)

D5 US 4 469 553 A (WHITEHEAD ROBERT E [US]) 4 September 1984 (1984-09-04)

ARTICLE 52 EPC

2 The present application does not meet the requirements of Article 52(1) EPC, because the subject-matter of claims 1 and 15 is not new in the sense of Article 54(1) and (2) EPC.

Amazon Ex. 1002.0092

2.1 D1 discloses (the references in parentheses apply to D1):

A method of projecting visual indicators (abstract) onto a physical object (col. 2, l. 12-19) to guide actions of an individual (abstract; col. 2, l. 1-6), said method comprising:
providing a guide system having a guide system controller (20, Figs. 1 and 2) and a projector (22, 24), said guide system controller including a plurality of addressed display features (col. 8, l. 5-28; Figs. 1A-1L; col. 12, l. 56-66; col. 12, l. 22-33; col. 13, l. 60 - col. 14, l. 7: the cited passages show that display features (VDF) are stored on the controller 20 of D1, which necessarily implies that addresses are associated to the display features);
providing an input signal to said guide system controller (col. 2, l. 9-10; col. 4, l. 43-44; col. 6, l. 58; see also col. 10, l. 58-66 and col. 17, l. 31-34);
selecting an addressed display feature based on said input signal (col. 2, l. 11-12; col. 4, l. 44-50; col. 6, l. 58-63; see also col. 13, l. 47-50: the input signal of D1 triggers a certain operation step; hence, the selection of a display features (VDF) as a function of the operational step implies a selection of VDF based on the input signal); and
projecting a visual indicator corresponding to said selected addressed display feature onto a physical object (col. 2, l. 12-19),

as defined in claim 1.

The subject-matter of claim 1 is therefore not new in view of D1.

2.2 D2 discloses (the references in parentheses apply to D2):

A method of projecting visual indicators onto a physical object to guide actions of an individual (abstract), said method comprising:
providing a guide system (Fig. 1) having a guide system controller (102, 104, 106, 108, 112, 126) and a projector (110), said guide system controller including a plurality of addressed display features (see 702-712 in Fig. 7);
providing an input signal to said guide system controller (the provision of the master design file, 202 in Fig. 2);
selecting an addressed display feature based on said input signal (par. 28; par. 38; 902 in Fig. 9); and
projecting a visual indicator corresponding to said selected addressed display feature onto a physical object (abstract; claim 1; par. 5),

as defined in claim 1.

The subject-matter of claim 1 is therefore not new in view of D2.

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2.3 Furthermore, the subject-matter of claim 1 is not new in view of D3 (see D3, the abstract, par. 20, 65, 67, 70 and 71). In particular, "step the operator 216 through a pre-defined set of holes" (par. 65 and 71) and the guidance of the operator through a pre-defined sequence of holes (see par. 67 and 70) implies an input signal for activating the projection of a graphic corresponding to the next hole in the sequence., i.e. the input signal defined in claim 1 of the present application.

2.4 Moreover, the subject-matter of claim 1 is not new in view of D4 (see par. 5, 12 and Fig. 1).

2.5 Furthermore, the subject-matter of claim 1 is not new in view of D5.

D5 discloses a method of projecting visual indicators onto a physical object to guide actions of an individual (abstract), said method comprising:
providing a guide system having a guide system controller (184, Fig. 8) and a projector (188), said guide system controller including a plurality of addressed display features (col. 10, l. 58-63; see also col. 19, l. 45-51 and claim 20; alternatively, see col. 9, l. 42-46);
providing an input signal to said guide system controller (claim 34; alternatively, the switch 152 in col. 9, l. 38);
selecting an addressed display feature based on said input signal (claim 34; col. 8, l. 5-14; alternatively, col. 9, l. 46-49); and
projecting a visual indicator corresponding to said selected addressed display feature onto a physical object (abstract).

2.6 The same objections apply, mutatis mutandis, to the subject-matter of claim 15.

3 Dependent claims 2-14 do not contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the EPC with respect to novelty (Article 54(1), (2) EPC) and/ or inventive step (Article 56 EPC), the reasons being as follows:

3.1 The positional identifiers defined in claim 2 are at least disclosed in D1 (see the recording of coordinates in col. 12, l. 56-66; see also col. 14, l. 8-39) and D3 (see par 67, 70 and 71).

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3.2 The manufacturing execution system and system controllers defined in claims 3, 4, 5, 6, 7 and 8 are obvious - if not implicit - from D1 (see col. 10, l. 58-64; col. 17, l. 31-34; see also col. 6, l. 24-28 and l. 43-47).

3.3 The additional features of claim 9 are known from D1 (col. 2, l. 34-37; Figs. 1A-1L and col. 8, l. 5-53).

3.4 The confirmation signal and the corresponding sensor apparatus defined in claims 10 and 11 are known from D1 (col. 2, l. 25-33; col. 9, l. 58 - col. 10, l. 29).

3.5 Recording images by a camera, as defined in claim 12, is not explicitly disclosed in D1, but would be obvious to the skilled person in order to improve monitoring of the operator actions (see col. 15, l. 56-col. 16, l. 19). Moreover, this step is known from D4 (par. 10 and 11).

3.6 The steps of recording and displaying time duration, as well as displaying a recorded image, as defined in claims 13 and 14, are known from D1 (see Fig. 5).

ARTICLE 84 EPC

4 The application does not meet the requirements of Article 84 EPC, because the claims are not clear.

4.1 The expression "addressed display feature" used in claims 1 and 15, and in particular the adjective "addressed", have no generally recognized meaning within the present context and thus lead to unclarity of the claims.

Fur the purpose of examining novelty and invetive step, the adjective "addressed" is interpreted as "having an address".

4.2 Because of the use of the indefinite article, it is unclear whether the "physical object" defined in the last line of claim 1 is the same "physical object" as defined in the first line of claim 1.

FURTHER MATTERS

5 It is not at present apparent which part of the application could serve as a basis for a new, allowable claim. Should the applicant nevertheless regard some particular matter as patentable, the applicant is invited to file new

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claims which take account of the above objections. Furthermore, upon continuation of the procedure, the applicant is invited to take account of the following points:

- Rule 43(1) EPC, two-part form of the claims;
- Rule 42(1)(b) and (c) EPC, conformity of the description to the new claims and reference to the background art;
- Rule 50(1) EPC, documents replacing documents should meet the requirements of Rule 49(5) and (8) EPC; in particular, the EPO will no longer accept handwritten amendments (OJ 12/2013, 603).

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Europäisches Patentamt
European Patent Office
Office européen des brevets

SUPPLEMENTARY EUROPEAN SEARCH REPORT

Application Number
EP 12 74 4452

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	US 7 515 981 B2 (RYZNAR PAUL [US] ET AL) 7 April 2009 (2009-04-07) * the whole document *	1-15	INV. G01C15/02 B23P21/00
X	US 2006/106483 A1 (BEHAN WILLIAM M [US] ET AL) 18 May 2006 (2006-05-18) * the whole document *	1-3,9-15	
X	US 2007/180674 A1 (MORDEN JARRAD V [CA] ET AL) 9 August 2007 (2007-08-09) * the whole document *	1-15	
X	DE 103 20 557 A1 (MARTIN MECHANIC FRIEDRICH MART [DE]) 9 December 2004 (2004-12-09) * the whole document *	1-15	
X	US 4 469 553 A (WHITEHEAD ROBERT E [US]) 4 September 1984 (1984-09-04) * the whole document *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

G05B
B23P

The supplementary search report has been based on the last set of claims valid and available at the start of the search.

Place of search	Date of completion of the search	Examiner
Munich	1 July 2015	Schriefl, Josef

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C04)

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 74 4452

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

01-07-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7515981 B2	07-04-2009	CA 2625348 A1	19-04-2007
		US 2008121168 A1	29-05-2008
		WO 2007044558 A2	19-04-2007
US 2006106483 A1	18-05-2006	US 2006106483 A1	18-05-2006
		US 2009037138 A1	05-02-2009
		US 2012004752 A1	05-01-2012
		US 2013203511 A1	08-08-2013
US 2007180674 A1	09-08-2007	EP 1928632 A2	11-06-2008
		JP 2009509785 A	12-03-2009
		US 2007180674 A1	09-08-2007
		WO 2007038740 A2	05-04-2007
DE 10320557 A1	09-12-2004	NONE	
US 4469553 A	04-09-1984	NONE	

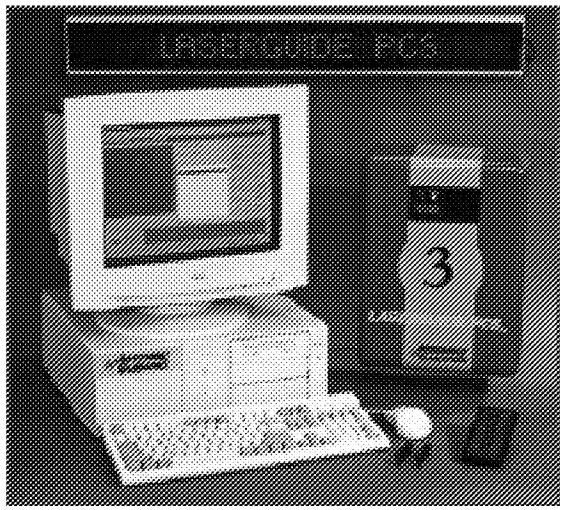
For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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ASSEMBLY GUIDANCE

LASERGUIDE

Projecting Accurate "Templates of Light" since 1988



"The laser ply projection system reduced the lay-up production time by 80 percent over conventional methods."

Steve Sucic, S92 Composite Rotor Blade Engineer, using LASERGUIDE at United Technologies

LASERGUIDE Control System

- **Simultaneous Active Datafiles:** 6
  Build more parts with fewer control systems
- **Projector:** PCS or MicroLASERGUIDE, 8 supported
  Add projectors to enable desired configurations
- **LED Billboard:** Scrolling characters seen from 50', 4 supported
  Operators receive independent messages while working at the tool
- **Remote Control:** RF, non-directional, 50' range, 4 supported
  All lay-up operations controlled independently from tool
- **Barcode Reader:** All standard formats, 2 supported
  Integrate LASERGUIDE with current manufacturing Barcode System
- **Data Compatibility:** Any laser system data, Vistagy FiberSim and EnCapta, CATIA Cover, metrology data, other CAD system and NC data
  Runs any 3D point data
- **Operating System:** Any current Windows operating system
  Conforms to customer OS standards
- **LG CAD Viewer:** Displays projectors, targets, patterns, data division between projectors, surface normals, projection fields
  Check data, projector configurations, tools
- **Electronic Work Instructions:** Associates .txt, .jpg, .tif, .rtf, .avi files with any ply
  Text, graphic and video instructions provided on a ply-by-ply basis
- **Foreign Language Interface:** English, French, Italian, German, Japanese, other languages upon request
  Interface, instructions and OS in operator's native language

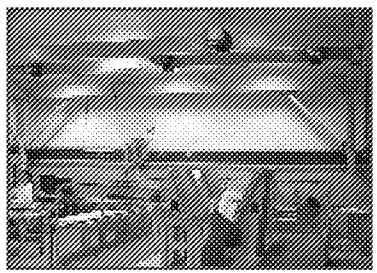
LASERGUIDE Projectors: PCS or MicroLASERGUIDE

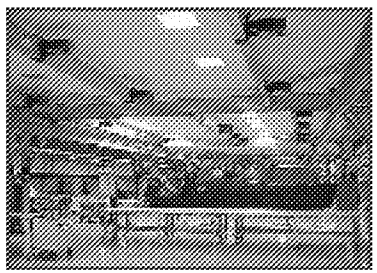
- **Pointing Accuracy:** .015" in standard field: 10'sq., 10' from projector (0,38mm in standard field: 3m^2, 3m from projector)
- **Retroreflective Targets:** 6 per projector. Targets mount in tooling pin holes or bushings and may be shared among projectors
- **Pattern Color:** Green or Red
- **Portability:** Single operator setup
- **Projector Range:** 3' to 40' (1m - 12m), auto-focus option available
  Sharp lines with varying projection distances
- **Simultaneous Projections on Independent Tools:** 4
  More operators work more parts with fewer projectors

Optional Automatic Ply Verification (APV): Verify/document ply presence, fiber orientation, edge location for unidirectional and woven composites
Prove that every ply of every part is built correctly. Errors detected and resolved at the lowest cost. Minimum change to manufacturing process

LASERGUIDE Integrations: Tape layers, fabric cutters, 5 axis ultrasonic core cutters, vision systems, compaction systems, metrology systems: laser radar, theodolites, laser trackers, CMMs

LASERGUIDE Support Structures: Custom steel structures, portable metrology instrument supports, attach to existing structures, automatic tilt







CE

Assembly Guidance Systems, Inc.
www.assemblyguide.com
sales@assemblyguide.com

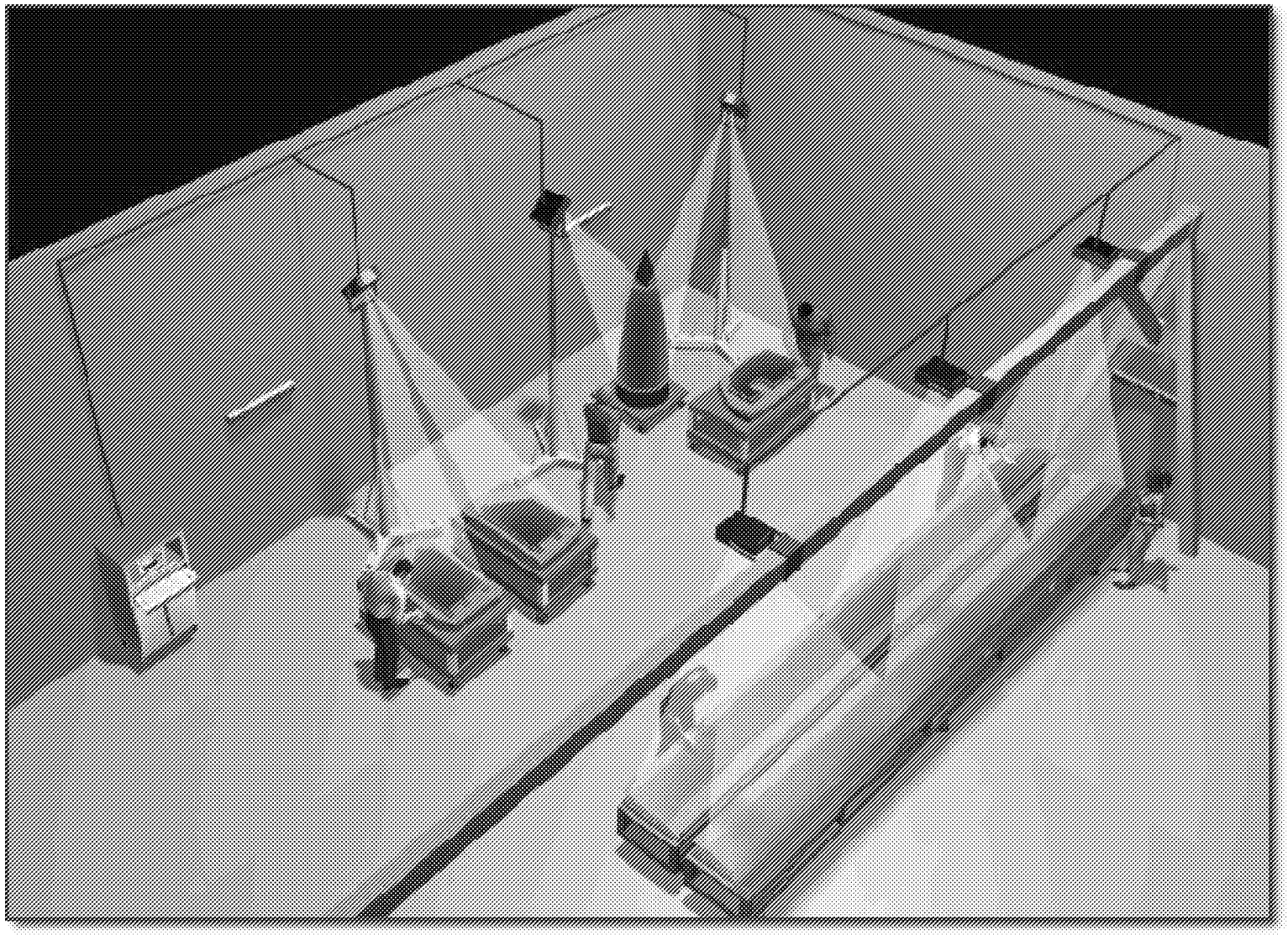
315 Littleton Road
Chelmsford, MA 01824, USA
(978) 244-1166 voice
(978) 244-9288 fax

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ASSEMBLY GUIDANCE

LASERGUIDE

productivity and flexibility



The only system with a single controller supporting multiple projectors, independent parts, and multiple patterns from any projector.

Assembly Guidance Systems, Inc.
www.assemblyguide.com
sales@assemblyguide.com

315 Littleton Road
Chelmsford, MA 01824, USA
(978) 244-1166 voice
(978) 244-9288 fax

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INTERNET ARCHIVE
Wayback Machine
http://www.assemblyguide.com/About%20Projection/AboutLaserProjectic Go
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2003 2004
10 captures
5 Dec 03 - 14 Jul 07

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Ply Verification

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Confined Area Projection

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Partners and Resources

News

About Laser Projection



The Value of Laser Projection in Manual Manufacturing

Doing the right things in the right places is a fundamental aspect of any manual manufacturing process. While this requirement may appear to be simple, there are many inefficient steps involved. In most cases, it is more costly and time-consuming to determine the correct location for a process than it is to perform it.

When using a blueprint showing where to drill, for example, a series of complex tasks must be performed before a hole can be drilled. In the simple case of drilling holes in a flat wall, the only value-adding task is the actual drilling itself. All other activity is overhead - required, but not directly adding value. These overhead tasks include:

1. ***Reading the blueprint*** - determining which of the shown tasks should be

performed first. (All tasks are shown at once on a blueprint)
2. ***Memorizing, from the blueprint, information for the specific task*** (such as dimensions, over and up, which define where a hole will be drilled)
3. ***Obtaining a measurement tool*** which allows the memorized dimensions to be accurately reproduced. (In the case of drilling, this may be a tape measure)
4. ***Positioning the tool*** (tape measure) so that the dimensions on the tool correspond to the ones shown on the blueprint
5. ***Marking the appropriate (memorized) dimensions***
6. ***Rechecking the measurements***
7. ***Putting the measurement tool away***

This sequence of overhead tasks is repeated as preparation to drill each hole. Frequently, the drilling surface is large or curved or requires high precision. In these applications, the creation, handling, deciphering, and storage of the measuring tool become significant non-value-adding costs. The overhead tasks also present many opportunities for human error. ("Measure twice, cut once.")

The information on a blueprint is generally created on a CAD system. The CAD system is used to produce the blueprint which is then used by the worker to perform the overhead tasks. The value-adding process cannot begin until all of the overhead tasks have been performed correctly.

In the picture shown above, the template (used in steps 3, 4, and 7 above) is a full-size storage of the dimensions defined in the CAD system. Without ***LASERGUIDE***, this template is the most efficient method for dimensioning.

Laser Projection with ***LASERGUIDE*** eliminates the overhead costs and problems. In the picture above, the green line visible on the tool is the pattern which would be marked from the template. At the touch of a button, ***LASERGUIDE*** projects accurate "templates of light" from 3D CAD data. Each individual step in the process is automatically displayed in the correct order and location. A rapid return on investment is the result of ***LASERGUIDE***'s process simplification.

As a cost-saving example, 80% of the manufacturing time, as well as the need for the large curved templates, was eliminated by ***LASERGUIDE*** in building helicopter blade skins. Each of the templates required two people for every operation; the cost of manufacturing each of these dimensional tools, replaced by ***LASERGUIDE***, was more than $10,000.

LASERGUIDE will eliminate costly overhead steps and tooling in your critical manual manufacturing processes. Assembly Guidance will work with you to develop a cost savings justification for ***LASERGUIDE*** in your manufacturing application.

LASERGUIDE Applications:

- Commercial, General Aviation, and Military Aircraft
- Regional Jets, Helicopters, Spacecraft
- Navy, Commercial, and Recreational Marine Applications
- Ground Transportation, Formula Racing Cars
- Integration with Wood, Metal, and Fabric Cutters, Tape Layers
- Integration with Metrology, Vision Systems, Compaction

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Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Paul Ryznar
Filer:	Karl T. Ondersma/Leslie Vredeveld
Attorney Docket Number:	RYZ01 P-101B

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	70	70
UTILITY SEARCH FEE	2111	1	300	300
UTILITY EXAMINATION FEE	2311	1	360	360
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**730**

Electronic Acknowledgement Receipt

EFS ID:	29260529
Application Number:	15600054
International Application Number:	
Confirmation Number:	6939
Title of Invention:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Paul Ryznar
Customer Number:	15671
Filer:	Karl T. Ondersma/Leslie Vredeveld
Filer Authorized By:	Karl T. Ondersma
Attorney Docket Number:	RYZ01 P-101B
Receipt Date:	19-MAY-2017
Filing Date:	
Time Stamp:	15:25:35
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$730
RAM confirmation Number	052217INTEFSW15264200
Deposit Account	505553
Authorized User	Karl Ondersma

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	01-Transmittal.pdf	277168 52daa47038869a41b6c6adda24d0d3d6f0041144	no	2
Warnings:					
Information:					
2	Miscellaneous Incoming Letter	02-ApplicationContinuationForm-RYZ01P101B.pdf	18686 8c14e3296d443d86c617a4a17f1ddbe479096132	no	2
Warnings:					
Information:					
3	Application Data Sheet	03-AppDataSheet.pdf	1793538 eb0a74342881d2f5bf4e13826b40aa6e6d266ae2	no	9
Warnings:					
Information:					
4		04-Application-RYZ01P101B.pdf	166875 671c9a60c9aacc7f232414461 02ba6c0870edc92	yes	34

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Specification	1	31
Claims	32	33
Abstract	34	34

Warnings:					
Information:					
5	Drawings-only black and white line drawings	05-AppDrwgs-P101B.pdf	2791205 3f21e6238fca569ed00dfbcc82293c1bb85ddb86	no	14

Warnings:					
Information:					
6	Oath or Declaration filed	06-Declaration.PDF	590408 d6e5f835477b5331333840988990026678130d2c	no	1
Warnings:					
Information:					
7	Information Disclosure Statement (IDS) Form (SB08)	07-IDS.pdf	613370 518265bf94266f78a3a9f0bd6444fe0f629e5968	no	7
Warnings:					
Information:					
8	Foreign Reference	Foreign01-DE000010320557A1.pdf	351213 848622ba1c00aaba99ee2bc3d2d7c24b44afef76	no	6
Warnings:					
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9	Foreign Reference	Foreign01DE10320557-translate.pdf	285683 d07967c39b490e6708a8fe5ab55a4c1c2ad2c5cf	no	5
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10	Non Patent Literature	NPL-01-WrittenOpinion.pdf	174889 7229a2e7f08eb86b1e5376a1d9a57510500813e9	no	3
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11	Non Patent Literature	NPL-02-ISRandWO.pdf	245820 a256166416ca7e92caa2ab23da4ebcc9c0f4319a	no	7
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12	Non Patent Literature	NPL-03-EuropeanSearchReport.pdf	233857 7558ea66302a41e5ec2851638f866ce17bf9d5eb	no	7
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13	Non Patent Literature	NPL-04-AssembleyGuidance-laserguide.pdf	233382 7efb856905c347b88ad2b7d81e84c54ff1a2966f	no	1
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14	Non Patent Literature	NPL-05-AssembleyGuidance-productivity.pdf	214641 42d94c365af6717cdd25e4eb16914644f78b8f02	no	1
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Information:					
15	Non Patent Literature	NPL-06-AssemblyGuidance-AboutLaserProjection.pdf	283710 cdeae81c8090ef4324329c0dbfdc095549cc9e0c	no	2
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Information:					
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Warnings:					
Information:					
			Total Files Size (in bytes):	8309200	

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT4423006

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
PAUL RYZNAR	08/08/2013
JAMES RYZNAR	08/08/2013

RECEIVING PARTY DATA

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State/Country:	MICHIGAN
Postal Code:	48167

PROPERTY NUMBERS Total: 1

Property Type	Number
Application Number:	15600054

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Address Line 4: GRAND RAPIDS, MICHIGAN 49546

ATTORNEY DOCKET NUMBER:	RYZ01 P-101B
NAME OF SUBMITTER:	KARL T. ONDERSMA
SIGNATURE:	/Karl T. Ondersma/
DATE SIGNED:	05/19/2017
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 1
source=Assignment-P101A#page1.tif

ASSIGNMENT

WHEREAS, Paul Ryznar and James Ryznar residing at 49601 Deer Run Drive, Northville, MI 48167 and 11535 Ryznar Drive, Belleville, Michigan 48111 - respectively (hereinafter referred to as Assignors), have invented certain new and useful improvements in **LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD** for which an International Patent Application No. PCT/US2012/024370 was filed on February 10, 2012, claiming priority of U.S. Provisional Patent Application Serial No. 61/441,897 filed on February 11, 2011, and for which an application for United States Letters Patent was executed on even date herewith.

WHEREAS, OPS Solutions LLC, a corporation of the state of Michigan, having an office at 49601 Deer Run Drive, Northville, MI 48167 (hereinafter referred to as Assignee), is desirous of acquiring the entire right, title and interest in and to said invention and in and to any Letters Patent that may be granted therefore in the United States and in any and all foreign countries.

NOW, THEREFORE, in consideration of the sum of one dollar ($1.00), the receipt of which is hereby acknowledged, and for other good and valuable considerations, Assignors hereby sell, assign and transfer unto said Assignee the full and exclusive right, title and interest to the said invention in the United States and in all foreign countries and the entire right, title and interest in and to any and all Letters Patent which may be granted therefore in the United States and in any and all foreign countries and in and to any and all divisions, reissues, continuations, continuation-in-part, and extensions thereof including the full right to claim for any such applications the benefits of the International Convention.

Assignors hereby authorize and request the Patent Office Officials in the United States and in any and all foreign countries to issue any and all of said Letters Patent, when granted, to said Assignee as the owner of the entire right, title and interest in and to the same, for the sole use and behoof of said Assignee, its successors and assigns.

FURTHER, Assignors agree to communicate to said Assignee or its representatives any facts known to Assignors respecting said invention, and testify in any legal proceeding, sign all lawful papers, execute all divisional, continuation, continuation-in-part, substitution, renewal, and reissue applications, execute all necessary assignment papers to cause any and all of said Letters Patent to be issued to said Assignee, make all rightful oaths and generally do everything possible to aid said Assignee, its successors and assigns, to obtain and enforce proper protection for said invention in the United States and in any and all foreign countries.

IN TESTIMONY WHEREOF, we have hereunto set our signature on the date appearing next to it.

Witness:	Inventor:	Date:
	Paul Ryznar	August 8, 2013
	James Ryznar	August 8, 2013

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/600,054	05/19/2017	2837	730	RYZ01 P-101B	3	2

CONFIRMATION NO. 6939

15671
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546

FILING RECEIPT

OC000000091670067

Date Mailed: 06/01/2017

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Paul Ryznar, Northville, MI;
James Ryznar, Belleville, MI;

Applicant(s)

OPS Solutions LLC, Wixom, MI;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 13/984,744 08/09/2013 PAT 9658614
which is a 371 of PCT/US2012/024730 02/10/2012
which claims benefit of 61/441,897 02/11/2011

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 05/25/2017

Amazon Ex. 1002.0111

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/600,054**

Projected Publication Date: 09/07/2017

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

Preliminary Class

318

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 15/600,054

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	70		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	300		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	360		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	3 minus 20 =	*	x 40 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*	x 210 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	730		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

To: sytsma@glbf.com,patents@glbf.com,clark@glbf.com
From: PAIR_eOfficeAction@uspto.gov
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Jun 01, 2017 04:02:19 AM

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Grand Rapids, MI 49546
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Application	Document	Mailroom Date	Attorney Docket No.
15600054	APP.FILE.REC	06/01/2017	RYZ01 P-101B

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/600,054	05/19/2017	Paul Ryznar	RYZ01 P-101B

CONFIRMATION NO. 6939

15671
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546

PUBLICATION NOTICE



Title:LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

Publication No.US-2017-0255186-A1
Publication Date:09/07/2017

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

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Application	Document	Mailroom Date	Attorney Docket No.
15600054	NTC.PUB	09/07/2017	RYZ01 P-101B

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/600,054	05/19/2017	Paul Ryznar	RYZ01 P-101B	6939

15671 7590 11/23/2018

Gardner, Linn, Burkhart & Ondersma LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546

EXAMINER
EVERETT, CHRISTOPHER E

ART UNIT	PAPER NUMBER
2116	

NOTIFICATION DATE	DELIVERY MODE
11/23/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

Vredeveld@gardner-linn.com
clark@gardner-linn.com
patents@gardner-linn.com

Amazon Ex. 1002.0118

Office Action Summary	Application No. 15/600,054	Applicant(s) Ryznar et al.	
	Examiner CHRISTOPHER E EVERETT	Art Unit 2116	AIA Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 5/19/2017.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-3 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-3 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 5/19/2017 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date 5/19/2017.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

1. Claims 1-3 are pending.

Notice of Pre-AIA or AIA Status

2. The present application is being examined under the pre-AIA first to invent provisions.

3. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 1 and 3 are rejected under pre-AIA 35 U.S.C. 102(b) as being unpatentable by U.S. Patent Publication No. 2005/0225753 (Engelbart).

Claim 1:

The cited prior art describes a guide system adapted to provide visual indicators to an individual to guide actions for a particular guided operation, said guide system comprising: **(Engelbart: "The method also includes automatically causing at least one light source to direct light at the composite structure to indicate the defect location(s) as defined by the positional data. Accordingly, the light allows the defect location(s) to be readily ascertained for later action, such as manual defect repair and/or FOD removal by an operator." Paragraph 0013)**

- a directional light device, said directional light device being selectively operable to project and target at least one indicating light; **(Engelbart: see the light source 14 as illustrated in figure 8 and as described in paragraphs 0092, 0094; "The light source 14 is positioned to emit light for illuminating the composite structure 22. The illumination is reflected differently by defects in the composite structure than from portions of the composite structure that are defect free. For example, illumination reflecting off non-defective portions of the composite structure 22, and light that fails to reflect off of defects in the composite structure 22, or vice versa, creates visible images that can be captured by the camera 12." Paragraph 0094)**
- a guide system controller, said guide system controller being operable to control said directional light device to project a visual indicator onto a physical object associated with the particular guided operation; **(Engelbart: "Operation 432 includes creating instructions or commands for the light source. Creating these instructions can include accessing the part fabrication file 402. These instructions can automatically**

cause (e.g., activate, steer, etc.) the light source to direct light at the composite structure to highlight or indicate the location at which a defect is located. Preferably, these instructions for the light source are automatically written based on NC block information and data from the inspection/vision system." Paragraph 0079; "According to another aspect of the invention, a system generally includes at least one light source and a controller associated with the light source. The controller is capable of accessing positional data defining one or more defect locations on the composite structure. Without operator assistance, the controller can automatically cause the light source to direct light at the composite structure to indicate the defect location(s) as defined by the positional data." Paragraph 0036)

- a camera located proximate to said directional light device and configured to image said visual indicator when projected onto the physical object; **(Engelbart: see the camera 12 as illustrated in figure 8 and as described in paragraph 0092; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**
- a monitor, said monitor being remote from said directional light device and said guide system controller, with said monitor being operably interfaced with said camera to display images from said camera. **(Engelbart: see the user interface 76 connected to the storage device 64 and processor 66 as illustrated in figure 8 and as described in paragraphs 0092, 0093; "The user interface 76 can includes a window in which an image of the composite structure is displayed for viewing by an operator or other**

user." Paragraph 0093; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)

Claim 3:

The cited prior art describes a method of projecting visual indicators to guide actions of an individual for a particular guided operation, said method comprising: **(Engelbart: "The method also includes automatically causing at least one light source to direct light at the composite structure to indicate the defect location(s) as defined by the positional data. Accordingly, the light allows the defect location(s) to be readily ascertained for later action, such as manual defect repair and/or FOD removal by an operator." Paragraph 0013)**

- projecting a visual indicator using a directional light device onto a physical object associated with the particular guided operation; **(Engelbart: see the light source 14 as illustrated in figure 8 and as described in paragraphs 0092, 0094; "The light source 14 is positioned to emit light for illuminating the composite structure 22. The illumination is reflected differently by defects in the composite structure than from portions of the composite structure that are defect free. For example, illumination reflecting off non-defective portions of the composite structure 22, and light that fails to reflect off of defects in the composite structure 22, or vice versa, creates visible images that can be captured by the camera 12." Paragraph 0094)**

- imaging the projected visual indicator with a camera located proximate to the directional light device; **(Engelbart: see the camera 12 as illustrated in figure 8 and as described in paragraph 0092; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**
- transmitting images from the camera to a monitor located remotely from the directional light device; and **(Engelbart: see the user interface 76 connected to and separate from the storage device 64 and processor 66 as illustrated in figure 8 and as described in paragraphs 0092, 0093; "The user interface 76 can includes a window in which an image of the composite structure is displayed for viewing by an operator or other user." Paragraph 0093; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**
- displaying images from the camera on the monitor. **(Engelbart: "The user interface 76 can includes a window in which an image of the composite structure is displayed for viewing by an operator or other user." Paragraph 0093; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**

Claim Rejections - 35 USC § 103

6. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

8. Claim 2 is rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over U.S. Patent Publication No. 2005/0225753 (Engelbart) in view of U.S. Patent Publication No. 2011/0178627 (Wechter).

Claim 2:

Engelbart does not explicitly describe a remote computer as described below. However, Wechter teaches the remote computer as described below.

The cited prior art describes the guide system of claim 1,

- wherein said guide system controller is configured to be selectively interfaced with a computer, said computer being remote from said directional light device and said guide system controller, **(Wechter: see the controllers 30, 32 and the remote monitoring and control systems as illustrated in figure 1 and as described in paragraph 0021; "The system controller 30 may be further linked to various remote monitoring and control systems, such as for downloading from a remote location manufacturing programs, component parameters, orders for products, and so forth, and for uploading to a remote location information relating to the manufactured products, their process through the system, success or failure of various processes and tests, and so forth. The remote connections may be based upon any suitable protocol, such as existing industrial data exchange protocols, Internet protocols, and so forth." Paragraph 0021)**
- with said monitor interfaced with said computer and with said computer configured to selectively operate said guide system controller. **(see the remote computer in Wechter and the monitor in Engelbart; Engelbart: see the user interface 76 connected to the storage device 64 and processor 66 as illustrated in figure 8 and as described in paragraphs 0092, 0093; "The system 10 may also include a user interface 76 that is in communication with the processor 66. The user interface can be programmed**

such that it can run from a wide range of software applications, including but not limited to DOS, Windows 98, Windows/NT, Windows 2000, Windows CE, Linux, Unix, and equivalents. The user interface 76 can include a display screen, such as on a computer monitor, and can also include an input device, such as a keyboard and mouse (not shown), for permitting an operator to move a cursor about the display screen and input various system settings and parameters. The display screen can also be touch-sensitive for permitting the operator to input the desired settings by manually touching regions of the display screen. The user interface 76 can includes a window in which an image of the composite structure is displayed for viewing by an operator or other user." Paragraph 0093; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092; Wechter: see the controllers 30, 32 and the remote monitoring and control systems as illustrated in figure 1 and as described in paragraph 0021)

One of ordinary skill in the art would have recognized that applying the known technique of Engelbart, namely, light positioning system for quality control, with the known techniques of Wechter, namely, a manufacturing system for quality control, would have yielded predictable results and resulted in an improved system. Accordingly, applying the teachings of Engelbart to provide light and camera control for quality control with the teachings of Wechter to use remote monitoring and control for quality control would have been recognized by those of ordinary skill in the art as resulting in an improved guide system (i.e., using remote control and monitoring for

a light positioning system of Engelbart based on the teachings of remote control and monitoring for quality control in Wechter).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to CHRISTOPHER E EVERETT whose telephone number is (571)272-2851. The examiner can normally be reached on Monday-Friday 8:00 am to 5:00 pm (Eastern).

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kenneth Lo can be reached on 571-272-9774. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would

like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Christopher E. Everett/
Primary Examiner, Art Unit 2116

Notice of References Cited	Application/Control No. 15/600,054	Applicant(s)/Patent Under Reexamination Ryznar et al.	
	Examiner CHRISTOPHER E EVERETT	Art Unit 2116	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20080121168-A1	05-2008	Ryznar; Paul	G05B19/41805	116/201
*	B	US-8027745-B1	09-2011	Freeze; Wayne S.	G06Q10/06	700/106
*	C	US-20110178627-A1	07-2011	Wechter; David	G05B19/41875	700/109
*	D	US-7307542-B1	12-2007	Chandler; Scott S.	H05B37/0254	340/12.31
*	E	US-20050225753-A1	10-2005	Engelbart, Roger W.	B29C70/384	356/237.1
	F					
	G					
	H					
	I					
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	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
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	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	Art Unit
	CHRISTOPHER E EVERETT	2116

CPC - Searched*		
Symbol	Date	Examiner
(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001)	11/15/2018	CEE

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Search of DAV using inventors	11/15/2018	CEE
Search of EAST using inventors, assignee, and text searches	11/16/2018	CEE
Search of (G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001) using text searches	11/16/2018	CEE
Search of 700/95 using text searches	11/16/2018	CEE
Review of file history and references from parent application no. 13/98444	11/15/2018	CEE

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/Christopher E. Everett/ Primary Examiner, Art Unit 2116	

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	Art Unit
	CHRISTOPHER E EVERETT	2116

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	11/15/2018								
	1	✓								
	2	✓								
	3	✓								

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Paul Ryznar et al.
Art Unit	
Examiner Name	
Attorney Docket Number	RYZ01 P-101B

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	7515981	B2	2009-04-07	Ryznar et al.	
	2	4222036		1980-09-09	Troukens	
	3	4163309		1979-08-07	Stuckler	
	4	4102568		1978-07-25	Miyagi	
	5	3986244		1976-10-19	Latanzi	
	6	3667104		1972-06-06	Chamillard et al.	
	7	3623066		1971-11-23	Norris	
	8	3600785		1971-08-24	Cook	

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Art Unit	
Examiner Name	
Attorney Docket Number	RYZ01 P-101B

	9	2682117		1954-06-29	Wales	
	10	7463368	B2	2008-12-09	Morden et al.	
	11	7433796	B2	2008-10-07	Behan et al.	
	12	7193696	B2	2007-03-20	Engelbart et al.	
	13	6317980	B2	2001-11-20	Buck, III	
	14	5341183		1994-08-23	Dorsey-Palmateer	
	15	4469553	A	1984-09-04	Whitehead	
	16	6000801		1999-12-14	Dillon et al.	
	17	6036319		2000-03-14	Rueb et al.	
	18	6170163	B1	2001-01-09	Bordignon et al.	
	19	6600476	B2	2003-07-29	Mathis et al.	

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	Examiner Name	
	Attorney Docket Number	RYZ01 P-101B

	20	7268893	B2	2007-09-11	Palmateer	
	21	5406176		1995-04-11	Sugden	

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	1	20060185181	A1	2006-08-24	Long et al.	
	2	20060059699	A1	2006-03-23	Krantz et al.	
	3	20040111901	A1	2004-06-17	Newcomer	
	4	20060106483	A1	2006-05-18	Behan et al.	
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	6	20050154431	A1	2005-07-14	Quistgaard et al.	
	7	20110178627	A1	2011-07-21	Wechter et al.	

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First Named Inventor	Paul Ryznar et al.
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Attorney Docket Number	RYZ01 P-101B

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	1	10320557	DE	A1	2004-12-09	Martin Mechanic Friedrich Mart		X

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Written Opinion of the International Searching Authority for International Application No. PCT/US2012/024730 completed June 14, 2012.	
	2	International Search Report and Written Opinion of the International Searching Authority for International Application No. PCT/US2006/39215, June 1, 2007.	
	3	Search Report issued by the European Patent Office for European Application No. 12744452.9 dated July 24, 2015.	
	4	Assembly Guidance System Inc.'s LASERGUIDE brochure, publication date unknown.	
	5	Assembly Guidance System Inc.'s LASERGUIDE Productivity and Flexibility brochure, publication date unknown.	
	6	Assembly Guidance System Inc.'s About Laser Projection Webpage, indicated to have been published November 2004.	

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	Filing Date	
	First Named Inventor	Paul Ryznar et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	RYZ01 P-101B

EXAMINER SIGNATURE			
Examiner Signature	/Christopher E. Everett/ (11/15/2018)	Date Considered	11/15/2018

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Paul Ryznar et al.
Art Unit	
Examiner Name	
Attorney Docket Number	RYZ01 P-101B

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

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See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl T. Ondersma/	Date (YYYY-MM-DD)	2017-05-19
Name/Print	Karl T. Ondersma	Registration Number	55894

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	23130	((directional visual) with (light guide)) same camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
L2	8928	(((directional visual) with (light guide)) same camera).ab,clm,bsum.	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
L3	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
L4	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
L5	8083	L3 L4	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
L6	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
L7	111	L6 and 2	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
L8	302	L6 and 1	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
L9	10	1 and 5	US-PGPUB; USPAT; FPRS; EPO;	OR	ON	2018/11/16 13:38

			DERWENT			
L10	6	2 and 5	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
L11	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
L12	1393	L11 and 1	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
L13	362	L11 and 2	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
L14	785	L11 and 6	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
L15	6	5 and 14	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
L16	13	9 10 15	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
S1	20	("4469553" | "20060106483" | "20070180674" | "5341183" | "6317980" | "7193696" | "7433796" | "7463368" | "20040111901" | "20060059699" | "20060185181" | "2682117" | "3600785" | "3623066" | "3667104" | "3986244" | "4102568" | "4163309" | "4222036" | "7515981").PN.	US-PGPUB; USPAT	OR	ON	2016/04/25 12:38
S2	1	("20080121168").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/04/25 12:40
S3	3	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/04/25 12:41

S4	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/04/25 12:41
S5	1	("2013/0325155").URPN.	USPAT	OR	ON	2016/04/25 12:41
S6	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S7	4	S4 S5	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S8	3	S2 S4	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S9	3	S3 S4	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S10	4814	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:57
S11	1106	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:57
S12	56653	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S13	72690	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S14	5833	S10 S11	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S15	572	S12 and S13	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S16	47	S12 and S14	US-PGPUB; USPAT; FPRS;	OR	ON	2016/04/25 14:00

			EPO			
S17	52	S13 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S18	96	S16 S17	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S19	464998	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S20	47163	guide adj3 system	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S21	127	S12 and S13 and S19	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S22	12930	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S23	190143	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S24	12	S22 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S25	12988	S19 and S23	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S26	617	S25 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:04
S27	48	S26 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:04
S28	2	("7515981").PN.	US-PGPUB; USPAT; FPRS;	OR	OFF	2016/08/12 11:43

			EPO			
S29	28	("20030073541" | "2682117" | "3600785" | "3623066" | "3667104" | "3986244" | "4102568" | "4163309" | "4222036" | "4318222" | "4469553" | "4890382" | "5119536" | "5430662" | "5506641" | "5801946" | "5910894" | "6224385" | "6658218" | "7027886").PN. OR ("7515981").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:43
S30	10	("20050128437" | "20110179624" | "20110243380" | "20110314001" | "6600476" | "7515981" | "7530019" | "8027745" | "8162486" | "8199108").PN. OR ("9412053").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:45
S31	20	("20030163219" | "20040225390" | "20050058969" | "20060085088" | "4961148" | "5771043" | "6188402" | "6345207" | "6453209" | "6477437" | "6725184" | "6788987" | "6819965").PN. OR ("8027745").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:56
S32	1	("20110178627").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/12 13:53
S33	4	("7307542").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/15 10:00
S34	2	("5406176").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/15 10:06
S35	4	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/15 15:39
S36	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/15 15:39
S37	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S38	4683	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S39	1106	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S40	57264	(guide adj2 (system control controller))	US-PGPUB;	OR	ON	2016/08/15 15:39

			USPAT; FPRS; EPO			
S41	74554	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S42	5702	S38 S39	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S43	48	S40 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S44	53	S41 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S45	98	S43 S44	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S46	478537	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S47	12652	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S48	193361	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S49	11	S47 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S50	13487	S46 and S48	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S51	625	S50 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S52	50	S51 and S42	US-PGPUB;	OR	ON	2016/08/15 15:39

			USPAT; FPRS; EPO			
S53	136	S35 S36 S37 S43 S44 S45 S49 S52	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S54	14	("6000801" | "6036319" | "6170163" | "6600476" | "7268893").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:21
S55	4	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/01/06 14:22
S56	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/01/06 14:22
S57	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S58	5375	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S59	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S60	60369	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S61	78761	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S62	6395	S58 S59	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S63	50	S60 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S64	54	S61 and S62	US-PGPUB; USPAT; FPRS;	OR	ON	2017/01/06 14:22

			EPO			
S65	101	S63 S64	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S66	504181	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S67	14080	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S68	202896	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S69	12	S67 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S70	14194	S66 and S68	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S71	625	S70 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S72	50	S71 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S73	139	S55 S56 S57 S63 S64 S65 S69 S72	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S74	139	S73	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S77	7	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 11:29
S78	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 11:29

S79	6	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S80	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S81	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S82	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S83	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S84	8083	S80 S81	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S85	57	S82 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S86	76	S83 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S87	127	S85 S86	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S88	613807	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S89	17531	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S90	238507	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29

S91	15	S89 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S92	17380	S88 and S90	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S93	626	S92 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S94	49	S93 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S95	165	S77 S78 S79 S85 S86 S87 S91 S94	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S96	165	S95	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S97	165	S96	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S98	72	("20040111901" | "20050154431" | "20060059699" | "20060106483" | "20060185181" | "20070180674" | "20110178627" | "2682117" | "3600785" | "3623066" | "3667104" | "3986244" | "4102568" | "4163309" | "4222036" | "4469553" | "5341183" | "5406176" | "6000801" | "6036319" | "6170163" | "6317980" | "6600476" | "7193696" | "7268893" | "7433796" | "7463368" | "7515981").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:31
S99	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-20110178627-$ or US-20050154431-$).did. or (US-7515981-$ or US-7463368-$ or US-7193696-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-	US-PGPUB; USPAT	OR	ON	2018/11/15 11:31

		7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.				
S100	9	S99 and camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 11:31
S101	1	("20050225753").PN.	US-PGPUB; USPAT	OR	OFF	2018/11/15 12:22
S102	3	((("OPS") near3 ("SOLUTIONS") near3 ("LLC"))).AS,AANM.	USPAT	OR	ON	2018/11/15 13:11
S103	8	((("RYZNAR") near3 ("Paul")) OR (("RYZNAR") near3 ("James"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2018/11/15 13:12
S104	8	S102 S103	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:12
S105	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-20110178627-$ or US-20050154431-$ or US-20050225753-$).did. or (US-7515981-$ or US-7463368-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.	US-PGPUB; USPAT	OR	ON	2018/11/15 13:29
S106	9	S105 and camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:29
S107	30	S105 and (camera image position)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:31
S108	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-	US-PGPUB; USPAT	OR	ON	2018/11/15 13:35

		20110178627-$ or US-20050154431-$ or US-20050225753-$).did. or (US-7515981-$ or US-7463368-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.				
S109	30	S108 and (camera position image)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:35
S110	19	S109 and guide	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:37
S111	1	S108 and (camera adj4 guide)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:38
S112	23	S108 and (camera guide)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:38
S113	111	S96 and guide	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:41
S114	576917	(camera).ab.clm.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:58
S115	709872	(camera).ab,clm.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:58
S116	229216	(camera).clm.ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:59
S117	709879	S114 S116	US-PGPUB; USPAT; FPRS;	OR	ON	2018/11/15 13:59

			EPO			
S118	7	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 16:36
S119	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 16:36
S120	6	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S121	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S122	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S123	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S124	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S125	8083	S121 S122	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S126	57	S123 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S127	76	S124 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S128	127	S126 S127	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S129	613807	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36

S130	17531	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S131	238507	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S132	15	S130 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S133	17380	S129 and S131	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S134	626	S133 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S135	49	S134 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S136	165	S118 S119 S120 S126 S127 S128 S132 S135	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S137	165	S136	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S138	165	S137	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S139	165	S138	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 16:36
S140	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 12:10
S141	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS;	OR	ON	2018/11/16 12:10

			EPO			
S142	8083	S140 S141	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 12:10

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S75	0	(selecting one more particular addressed display features by said guide system controller from the plurality of said addressed display features based on said input signals wherein said input signals control selection of said addressed display features based on the address identifier for the said addressed display feature projecting one more visual indicators corresponding to said selected particular addressed display features onto one more physical objects associated with the particular guided operation with said guide system controller configured to control operation of said projector to project said visual indicators based on said input signals wherein said guide system controller is operative to receive any sequence of input signals from the separate computer system controller to dynamically control projection of any sequence of said visual indicators corresponding to respective said addressed display features based on said input signals corresponding to desired visual indicators for the particular operation with a combination of the sequence of input signals resulting in a creation of a dynamic real time projection of visual indicators).clm.	US-PGPUB; USPAT	AND	ON	2017/01/06 14:30
S76	0	(selecting one more particular addressed display features by said guide system controller from the plurality of said addressed display features based on said input signals wherein said input signals control selection of said addressed display features based on the address identifier for the said addressed display feature projecting one more visual indicators corresponding to said selected particular addressed display features onto one more physical objects associated with the particular guided operation with said guide system controller configured to control operation of said projector to project said visual indicators based on said input signals wherein said guide system controller is operative).clm.	US-PGPUB; USPAT	AND	ON	2017/01/06 14:30

11/ 16/ 2018 1:40:56 PM
C:\ Users\ ceverett\ Documents\ EAST\ Workspaces\ 15600054-LightGuidedOperation.wsp

To: Vredeveld@gardner-linn.com,clark@gardner-linn.com,patents@gardner-linn.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 15671

Nov 23, 2018 03:50:10 AM

Dear PAIR Customer:

Gardner, Linn, Burkhart & Ondersma LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546
UNITED STATES

The following USPTO patent application(s) associated with your Customer Number, 15671 , have new outgoing correspondence. This correspondence is now available for viewing in Private PAIR.

The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

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LuminAR

A Compact and Kinetic Projected Augmented Reality Interface

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Natan Linder

B.A. in Computer Science, The Interdisciplinary Center, May 2003

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning,
in partial fulfillment of the requirements for the degree of
Master of Science in Media Arts and Sciences
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September 2011

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LuminAR

A Compact and Kinetic Projected Augmented Reality Interface

Natan Linder

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning on August 6, 2011
in partial fulfillment of the requirements for the degree of
Master of Science in Media Arts and Sciences
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Abstract

For quite some time, researchers and designers in the field of human computer interaction have strived to better integrate information interfaces into our physical environment. They envisioned a future where computing and interface components would be integrated into the physical environment, creating a seamless experience that uses all our senses. One possible approach to this problem employs projected augmented reality. Such systems project digital information and interfaces onto the physical world and are typically implemented using interactive projector-camera systems.

This thesis work is centered on design and implementation of a new form factor for computing, a system we call LuminAR. LuminAR is a compact and kinetic projected augmented reality interface embodied in familiar everyday objects, namely a light bulb and a task light. It allows users to dynamically augment physical surfaces and objects with superimposed digital information using gestural and multi-touch interfaces. This thesis documents LuminAR's design process, hardware and software implementation and interaction techniques. The work is motivated through a set of applications that explore scenarios for interactive and kinetic projected augmented reality interfaces. It also opens the door for further explorations of kinetic interaction and promotes the adoption of projected augmented reality as a commonplace user interface modality.

This thesis work was partially supported by a research grant from Intel Corporation.

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LuminAR

A Compact and Kinetic Projected Augmented Reality Interface

Natan Linder

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Totum factum.

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1 Introduction

The Current User Interface Challenge

We live in an era in which user interface design is central to the perception, creation and adoption of technology. It is in this same era that human society at large, has become almost completely technology-dependent. Battery powered electronic devices with digital interfaces now connect us to vast networks of information. In less than 30 years, we have miniaturized our personal computers to a hand held size. We can package enough computation in a matchbox to carry out massive processing that once required a room full of servers. We also expect wireless communication as we expect electricity.

The digital world has become an integral aspect of everything we do; whether it is work or play. We take it for granted that we can connect anywhere, anytime and gain access to any information. Only in the past few years has the web transformed into a cloud of services. At the same time, embedded computing, wireless communication and novel UI technologies matured quickly to a point where we think we have the Internet at the tip of our fingers at all times, but do we really? This thesis raises this question and asserts that there is in fact a discontinuity between our experiences in the physical world and our interactions with the digital world.

The problem is that the real world is complex, and we are still using it very much physically. Our current work environment, such as lab benches, architect tables and retail counters, provide a case in point for how we really work: multiple devices, notes, paper and various tools and objects. So in reality - the digital world and the physical world are not at all disconnected. A note we write finds its way to an email message, and a measurement we take will end up in a CAD model.

In reality, users have the responsibility of connecting the digital and the physical world. We humans did not evolve as quickly as our technology, and fundamentally, we have a very narrow pipe to process the vast amounts of information we can now reach. Our brains and sensory systems define a biological I/O bottleneck that we work hard to overcome, mainly because as users we have adapted ourselves to interfaces and not vice versa.

New Form Factors for Computing

It is very likely that the roots of this problem lie in the evolution of computing devices form factors. Essentially, we are still using display-centric devices, and as such they define the key modality of interaction, which hasn't changed substantially since the PC. I believe that humans are spatial creatures that were not 'designed' to spend most of their time in front of computers. And yet it seems that more and more of our work and play hours are spent in front of a screen. This defines an

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'interface paradox' from a cognitive, ergonomics and design point of view - we are designing interfaces that change our essence. The direct impact of this phenomenon is at the core of thought and discourse of modern sociologists. Vast research is being carried out in an effort to define and measure how human perception, thinking and behavior is altered due to the massive proliferation of technology and interfaces to the digital world.

Another aspect of this meta-problem is the fact that we are constantly curating several consumer electronic devices that connect us to the digital world: laptops, smart-phones, e-book readers, digital cameras and the list goes on. We are responsible for updating software, running cables, charging, syncing and so on. Unfortunately, Wieser's Ubiquitous Computing vision [1] still seems far away, and poses a challenge to Human Computer Interaction research. Technology has yet to become transparent and embedded in our environment.

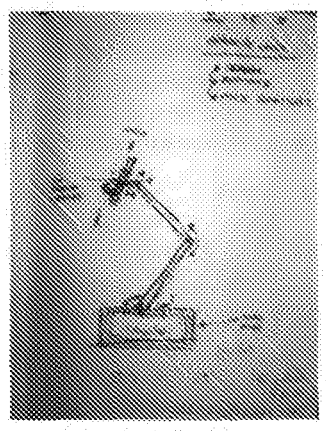
Projected Augmented Reality Interfaces

To address the challenges I introduced above, researchers and designers in the field of human computer interaction have pursued the research of augmented reality systems as a means to better integrate information interfaces into our physical environment. They envision a future where computing and interface components will be integrated in the physical environment, creating a seamless experience that uses all our senses.

One possible approach to this problem employs projected augmented reality [2]. Such systems project digital information and interfaces onto the physical world and are typically implemented using interactive projector-camera systems. However, classic projector camera systems are very limited as we discuss in detail in the next chapter.

Kinetic Projected Augmented Reality Interfaces

This thesis work is centered on the design and implementation of a new form factor for computing, a system we call LuminAR [3]. LuminAR is a compact and kinetic projected augmented reality interface embodied in familiar everyday objects, namely a light bulb and a task light. It allows users to dynamically augment physical surfaces and objects with superimposed digital information using gestural and multi-touch interfaces.



LuminAR concept sketch

The goal of this thesis is to advance the state of the art of projected augmented reality interfaces. We intend to provide designers and engineers with a full-blown

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implementation of a compact and kinetic system that is feasible to build with current technology.

Another goal of this work was to provide a glimpse into the future potential applications of this technology in relevant real-world scenarios. We have focused on two areas: (1) future desktop environments and (2) augmented retail spaces.

The work on these applications enabled to distill a set of new interaction methods. These new techniques make use of the unique form factor components of the LuminAR system and their respective kinetic capabilities.

Finally, after several iterations of prototyping, we were able to refine our design and reach another goal of this work – embedding interface technology in everyday objects. In this work we emphasize the industrial and product design aspects, and part of the story this thesis tells is the one of the actual process in which we have refined our prototypes and achieved this goal.

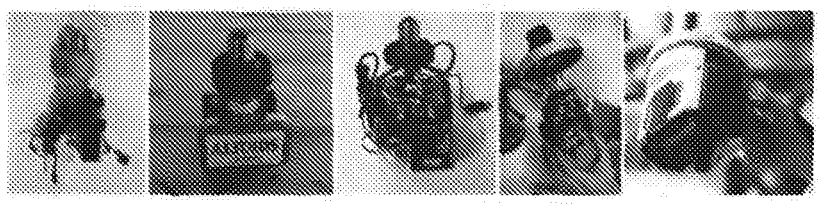
LuminAR Prototypes

We have developed three different systems that we used to explore the space of kinetic projected augmented reality interfaces: The LuminAR Bulb, LuminAR Lamp and the LuminAR Spotlight. The insights we derived from these prototypes can hopefully stir the discussion on a set of design principles for self contained, compact kinetic interfaces and associated interaction techniques.

We provide a brief description of the prototypes below.

LuminAR Bulb

The LuminAR Bulb design is a fully realized two-way information device. The bulb was designed to require only AC power and wireless communication to operate. It was designed to fit in existing, standard Edison lamp sockets. The bulb is a compact and completely self-contained projector-sensors system that integrates a laser pico-projector, cameras, sensors, control electronics, power supply and an embedded wireless computer in the size of a large bulb. In addition, the bulb has a rotational degrees-of-freedom (DOFs).

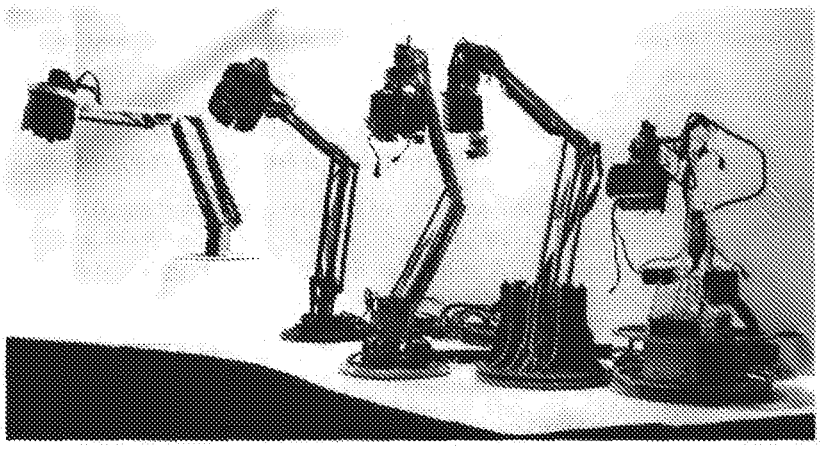


The evolution of LuminAR Bulbs

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LuminAR Lamp

The LuminAR Lamp is an articulated robotic arm, designed to interface and carry the LuminAR Bulb. The lamp's design follows the classic Anglepoise counter-balanced arm design allowing the bulb four DOFs. Each DOF has a motor, positional and torque sensors as well as motor control and power circuitry. The arm terminates in a lampshade with a standard Edison socket.



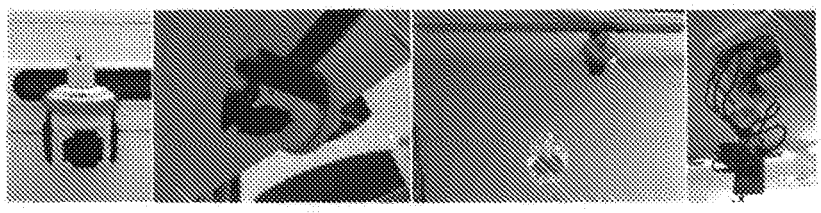
The evolution of LuminAR Lamps (photo: Doron Gild)

LuminAR Spotlight and Spotlight360

The LuminAR Spotlight system is an actuated track light. It is also designed to carry the LuminAR Bulb. The Spotlight can be mounted on a ceiling or wall, taking advantage of additional height and projection angles above and around a workspace.

The system consists of a linear track and a carriage with a tilting head, giving LuminAR Spotlight two degrees of freedom. The head interconnects with the LuminAR bulb through a standard Edison bulb screw socket. Spotlight's design is simple, allowing it to become almost invisible in its environments.

The Spotlight360 is another prototype for a wall or ceiling mounted LuminAR Bulb fixture, capable of rotating in 360 degrees. It is also mounted on a base servo that allows the bulb with an additional DOF.



LuminAR Spotlight and Spotlight360

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Contributions

This thesis work makes contributions in different areas, but mostly in the design and implementation of a compact and a kinetic form factor for a projected augmented reality interface. Specifically, the LuminAR project makes contributions in the following areas:

Hardware Engineering

- Provide a compact design for an actuated 1-DOF interactive projector-sensor system with a standard Edison socket interface. This design greatly reduces the complexity involved in designing and installing projector camera systems, and enables a simple, environmentally adaptable form factor
- Design and implementation of a kinetic projected reality interface with 5-DOF in a lamp form factor. This design enables the dynamic control of kinetic displays in terms of location, size and orientation of the display
- Design and implementation of ceiling and wall mounted kinetic projected augmented reality interfaces. This design allows for such interfaces to be easily installed in a physical space

Software Framework

- The design and implementation of an open and extensible software development environment that allows for easy application development for kinetic augmented reality applications

Interaction Techniques

- Design and implementation of a kinetic user interface methods with the ability to change point-of-view of projection and sensing using multiple DOF actuation, providing a more integrated and dynamic augmented reality experience
- Implementation of two-way input-output mechanisms supporting multiple modalities that combine natural user interfaces in real-time. For example providing object recognition and tracking in combination with traditional multi-touch or gesture recognition
- Defining and prototyping a set of new gestures we call *Dynamic Multi-touch,* that combine the traditional multi-touch interface with kinematic capabilities
- Context aware systems that can respond to user context and using kinematics can provide *just-in-time-and-place* interfaces

Applications

- Design and implementation of a set of novel augmented desktop applications, including the use of a spatial locative memory for menus and applications, as well as a gesture controlled kinetic application desktop prototype

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- Design and Implementation for a full future scenario for an augmented retail environment, including interfaces that augment products on a display counter, embedding rich media in a new shopping experience, also allowing interaction with a remote expert

Product/Industrial Design

- Creating novel and fully implemented designs for a new form factor for computing, these interface objects push the boundary beyond a lab prototype result in terms of functionality and aesthetics

It is my hope that the result of this work can open the door for the adoption of augmented reality as a commonplace user interface modality. This thesis only touches upon the interaction techniques enabled, leaving additional assessment and formal evaluation to future work.

Thesis Outline

This thesis is divided to seven chapters. Below is a chapter-by-chapter breakdown:

Chapter 1: Introduction provides a high level review of the current interface challenges this thesis addresses and a brief overview of the LuminAR project

Chapter 2: Background and Related Work provides motivation for this thesis work. It covers the relevant human computer interaction theory and the previous work in augmented interactive spaces, multi-touch and gestural interfaces as well as personal robotics. It also positions the work with the context of projected augmented reality interfaces.

Chapter 3: LuminAR contains the design and implementation details of the various LuminAR prototypes. It also includes the description of the LuminAR's LuXor software stack.

Chapter 4: Interaction Techniques outlines proposed kinetic interaction methods supported by LuminAR

Chapter 5: Applications provides a comprehensive review of the applications created to test the LuminAR systems, focusing on the Augmented Desktop and the Augmented Product Counter

Chapter 6: User Experience presents user feedbacks and the collective findings from the various LuminAR live demos

Chapter 7: Conclusion and Future Work summarizes the lessons learned. It also provides an outlook for proposed future work as well as a long-term vision.

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2 Background and Related Work

Motivation

This thesis is motivated by the desire to evolve new form factors for computers that explore further the yet unfulfilled promise of ubiquitous computing [1]. Computers have transformed human society. They carry the power of information, communication and creation to almost every aspect of our lives. However, it seems that we humans have adapted ourselves to our technology and not vice versa. Our interaction with digital information is dictated predominantly by screen based form factors and various input devices.

Interaction with digital information devices poses a challenge to us humans, as effectively we have become our very own human-computer I/O bottleneck. As we curate more devices and more connected devices, the complexity of using them increases. The goal of this work is to design new form factors that address this problem space directly from two key directions: (1) create fluid interfaces that seamlessly blend digital media with the real world, and (2) design form factors that embed computation in everyday objects.

Both approaches are still considered very much open challenges, though recent years have shown the potential and feasibility of combining the two. To stir the discussion of the related work, this section provides a quick overview of the key streams of HCI research that serve as foundations for the work presented here.

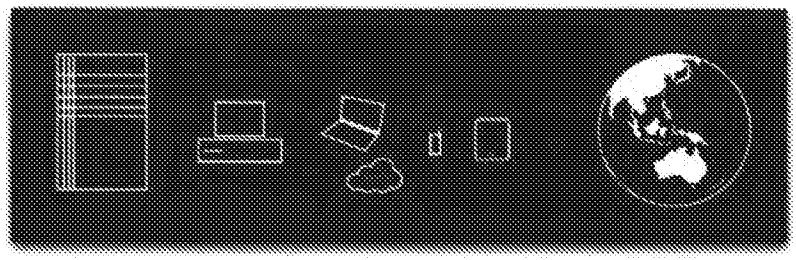
By the early eighties the personal computing revolution was well underway. PCs were powered by affordable microprocessor and had interfaces that at the time seemed reasonable for normal people to use, namely the keyboard, screen and the mouse. At the same time, another revolution was brewing, and a decade later Tim Berners Lee completed his work on the World Wide Web [4], and the Internet became a practical means to communicate and share digital media and information.

Both revolutions are in debt to pioneers like Vannevar Bush and Douglas Engelbart. Engelbart as early as 1968, demonstrated in the Mother of all Demos [5], what Bush has envisioned in his famous article to The Atlantic Monthly technology section: "As we may Think"[6]. Their work had possibly the most profound impact on the interfaces we actually use to interact with computers. Soon the adaptation of computer-based applications into daily life became a reality.

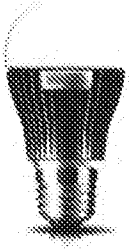
Spreadsheets, video games, word-processing were just a few early examples. Nowadays, it seems hard to find a niche where computers and networks did not invade. It was not long before HCI researchers and product designers realized that the benefits of computing,

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networking and digital media also pose a great interface challenge. Researchers Mark Wieser and Hiroshi Ishii coined the terms Ubiquitous Computing and Tangible User Interfaces respectively [1], [7]. Both envisioned a future where computers become invisible, and interfaces to digital information become embedded in everyday objects.



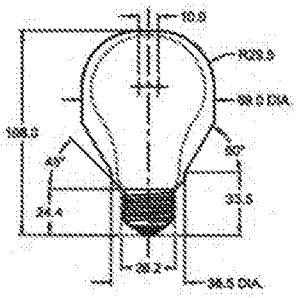
The evolution of computer interfaces. More than 40 years ago mainframe computers introduced a display centric user interface paradigm. This paradigm prevailed as interfaces miniaturized over the years. In the next era of user interfaces, our physical world will become our interface, where objects, surfaces, spaces become interactive, offering relevant information, based on context and interests of user.



Philips MASTER LEDBulb (source: Philips)

The notion that the physical world is still relevant to how we actually interact with digital media spawned a mass of research. Several projects pursued post-desktop, post-WIMP (Window, Icon, menu, pointing device) interactions. Examples of such research domain include: virtual reality (VR), augmented reality (AR), pervasive computing, context-aware computing, multi-touch and gestural interfaces.

Human Computer interaction research has been strongly influenced by these ideas of "ubiquitous computing", and vast efforts to implement some of these ideas have emerged over the years. AR is a good example of one such effort. There are several approaches in AR, some using goggles or glasses, others using handheld displays that blend digital information into the visual scene. In this thesis, I am particularly interested in Projected Augmented Reality systems (PAR) or AR interfaces that are implemented using Projector-Sensor systems.



NEMA A19 Bulb Specification C78.20-210. (source: NEMA)

Another aspect of the interface challenge was well captured in the famous debate between Ben Shneiderman and Pattie Maes that juxtaposed Direct Manipulation vs. Interface Agents [8]. Maes suggested that computers interfaces are no longer self-contained and that computer screens became windows to vast networks of information, foreseeing the Cloud Computing era. She also discussed how computer interfaces were designed with 20 years old set of assumptions that are out of date.

Today, even though much progress was made, many of our interfaces are still designed with the same set of direct manipulation assumptions, which manifest in interface modalities of display centric devices (e.g. a tablet, a smart phone or a laptop computer).

LuminAR makes contributions to several technical and design domains. In this chapter I will review and position the contributions of this thesis

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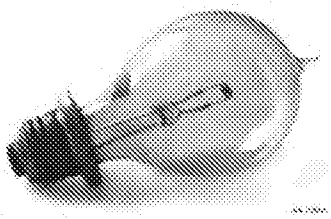
in the technical domain of projected augmented reality systems and interfaces. I will also situate the work in the relevant product and industrial design territories.

Design Space

LuminAR is an attempt to embed computation and interfaces in everyday objects. In this section we would like to provide the reader with a short background describing the history of the incandescent bulb, the Anglepoise lamp and the Track light fixture to provide context for our design considerations discussion further on in this document (See Chapter 3).

Lamps and Light bulbs

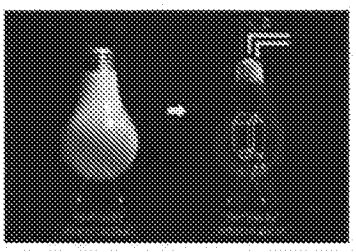
The discovery that a passage of electrical current through a filament creates light was completed in the early 1800s. It would take another eighty years or so for Thomas A. Edison to commercialize successfully the invention of the incandescent light bulb [9]. Since then, bulbs in various shapes, forms and technologies became an integral part of our habitats and urban spaces. The world adopted electric lights and never looked back.



Edison Patent Model Lamp No. 10 (source: Edisonian Museum Antique Electric Exhibits 1830 - 1930)

Humans have tried to tame the medium of light for a very long time. It is possible that first lamps were natural objects that were filled with moss or other combustible material and were then lit. Pottery soon followed, the Greeks have become proficient in making terra-cotta lamps, and word lamp is derived from the Greek word lampas. This evolution continued and over the centuries with candle lamps, oil lamps and gaslights. It is likely that this history influenced the design and the adaptation of the modern light bulb.

The General Electric Company led the way for this massive adaption in the US, pushing a set of standards for bulb power socket [10], [11]. These standards supported the needs of infrastructure development, as well as the business ecosystem of manufacturers, utilities companies and electricians.



I/O Bulb concept by John Underkoffler et al, 1999

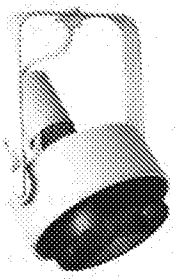
Standards are important as they help reduce complexity and cost of integration when adapting new solutions to the masses. One of LuminAR's design goals was to adhere to existing power standards, while keeping the design open to emerging power standards such as Power over Ethernet (PoE) and DC power distribution grid [12].

Along with advancement in infrastructure, light bulbs are constantly evolving. The driving force for the recent innovation in bulb design comes from Solid State Lighting (SSL) technology. Specifically the integration of Light Emitting Diodes (LED) elements into new bulb design can substantially reduce energy consumption [13]. Another advantage lies in the fact that LED can be designed to be multichromatic, which has a greater impact when such bulb are deployed in dynamic lighting systems. Matt Aldrich from the Responsive Environment group at the MIT Media Lab provides an excellent review of the field in his thesis [14].

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Clearly we can't imagine our habitats today without electric lights. Marshal McLuhan described the light bulb as a medium without content saying that "... a light bulb creates an environment by its mere presence, ..." [15]. Later on John Underkoffler would build on this theory and suggest that the bulb should evolve into a two-way information device [16]. Later in this section we will position the LuminAR bulb in design and technical context to the I/O Bulb, while the design and engineering of our bulb is detailed in Chapter 3.

Track Lights



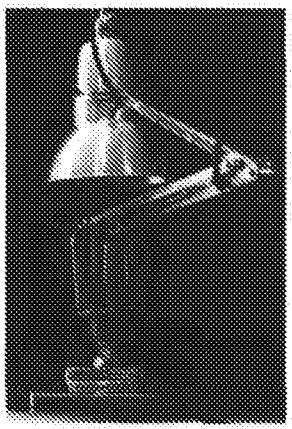
Lightolier Track iLight, 1960
(source: Lightolier)

The LuminAR Spotlight system is an actuated track light. Track lighting is a method of attaching multiple light fixtures to a continuous conductive track. This method is fundamentally different than routing electric power to each individual lighting element. Track lights often operate DC current, employing a master transformer from the AC grid. Tracks can be mounted on walls and ceiling. Fixtures can be spotlights, floodlight or reflector (or others), once positioned on the track; the space lighting can be easily customized.

Lightolier invented Track Lighting in the early 1960's [17] , since then several many manufacturers produced several designs and products.

The Anglepoise Task Light

George Carwardine a British engineer and freelance design consultant, invented several of the mechanisms for car suspension. The key novelty of his invention involved the creation of counterbalancing devices, designed to support a payload in a given three-dimensional position. The core of his mechanical innovation is in a new type of spring which could be extended easily in every direction yet remain rigid when set in a position. When the springs are mounted in sequence, it is possible to devise an equilibrator device that is light and compact and has low inertia.



Anglepoise Lamp, 1932
(source: Wikipedia)

Since then, a multiplitude of configurations were designed and implemented in products [18]. French and Widden have provided an excellent mechanical engineering overview to Carwardine's spring-and-lever balancing mechanisms [19] which we recommend to readers who are interested in the physics, and mathematics that govern this fascinating system.

Carwardine thought of many different uses for his invention before applying it to lamps. He explored the mounting of power tools, microphones, mirrors and copyholders. Eventually, he designed and built the first counterbalanced task light. It was initially named Equipoise, and later on changed to Anglepoise. The key advantage of the new device was clear; light fixtures could now be repositioned to illuminate specific locations. Mounting a shade on the lamp created a focused beam that consumed less energy. Carwardine believed that it would be useful for office workers, providing a personal task light, but also considered use in factories, dentist clinics and operating theaters.

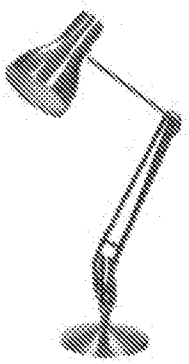
More than 70 years after its invention, the Anglepoise lamp, and its descendants (e.g. the classic Luxo lamps) became staple design

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objects that celebrate form and function, due to the simplicity of the design and the obvious ergonomics benefits. For product designers, the Anglepoise lamp form has iconic status, much like the chair has within furniture design.

Deyan Sudjic recently discussed the key design aspects of the lamp he described it as an object that is part technology and part artifice [20]. He summarized the key design questions involving the Anglepoise:

> *"The Anglepoise is a brilliant synthesis of structure and mechanism, it's possible that it might have something to do with the sheer scope that an adjustable lamp offers, it's mix of technology and artifice. There is the whole question of the mechanism, the way that the structure is articulated to make finger tip pressure movement possible, then there is the structure itself and the means that the light source is powered and controlled. Finally, as critical as all the other elements, is the quality of the light source and the way it is diffused, directed and shaded."*
>
> *-- Deyan Sudjic, Director of the London Design Museum*



Anglepoise Type 75
(source: Anglepoise)

It is the challenge of designers to answer the questions above when reinterpreting the classic form. It is a complex equation of functional requirements combined with technology, materials and aesthetics.

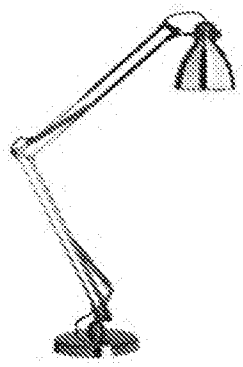
It is in this context that is relevant to briefly review lamp designs that served as a source of inspiration for LuminAR:

Anglepoise, Type 75

Designed by Kenneth Grange This version of the Type75 was launched in 2004 and was a redesign of the original 1970's Anglepoise.

Luxo L1

Designed by Jac Jacobsen in 1937. Originally designed as an 'architect lamp'. 25 million L-1 luminaires have been sold worldwide, and the lamp is considered a classic design that stood the test of time.



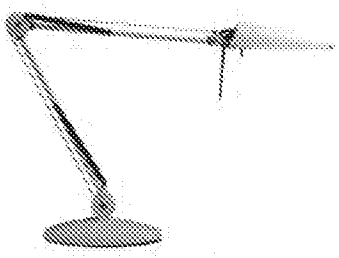
Luxo L1
(source: Luxo)

Luxo Air LED 8132 - 8133

Designed by Jukka Setälä in 2009. Air LED is using LED technology, consuming only 9 Watts. It is also the standard issue task light at the new Media Lab building. Air LED will operate for 25 years in a regular office setting or more than 5 years in continuous use.

Artemide, Tizio

Original 1972 design by Richard Sapper. Featured in the London Design Museum and the Museum of Modern Art (MoMA), New York. The design is based on a cantilevered rod structure to carry power to the lamp without cables.



Luxo Air LED 8132 - 8133
(source: Luxo)

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Details, Personal Underline

Design by Details a Steelcase company. The Personal Underline Light is streamlined, small, and very powerful LED task light, specifically designed for desk workspaces.

Polymer Light

Designed by Dirk Winkel in 2010. Polymer light is design exposes the use of gas springs, which facilitate a smooth movement. The lamp arms are made from solid plastics.



(a) (b) (c)

(a) Details, Personal Underline (b) Polymer Light by Dirk Winkel (c) iGuzzini / Ron Arad PizzaKobra (sources: Details, RCA, iGuzzini)

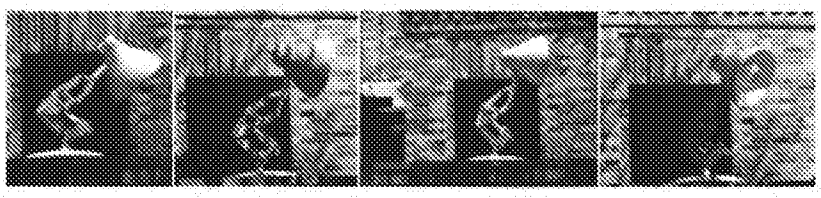
iGuzzini, PizzaKobra

Designed by Ron Arad in 2007. This work may have captured a future trend of task light design. Arad defined the task light as an object of desire. Below is how the designer described his provocative and unconventional task light:

> *"What does a task light do in the daytime? What can we do to make it look good, even when it's off? Who needs a crane on the desk when it has no job to do?*
>
> *How can we make it fully adjustable without it looking like a piece of technical equipment? I think it's a big job and needs a snake charmer, isn't amazing what can come out of a pizza box?" – Ron Arad*

Luxo Jr., Pixar

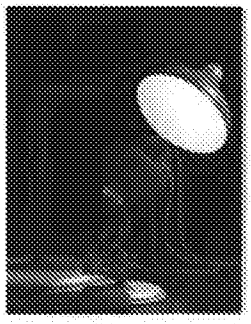
Designed by John Lasseter for Pixar Animation Studios in 1986. Even though Luxo Jr. is not a physical lamp, Lasseter's character explored the realm of possibilities of an articulated lamp.



Animatronic Luxo Jr. in Disney's theme park

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It gave life to an inanimate object and sparked the imagination of researchers and product designers [21], [22]. Disney has also created a life like robotic version for its theme park.



Pixar's Luxo and Luxo Jr.

Conclusion

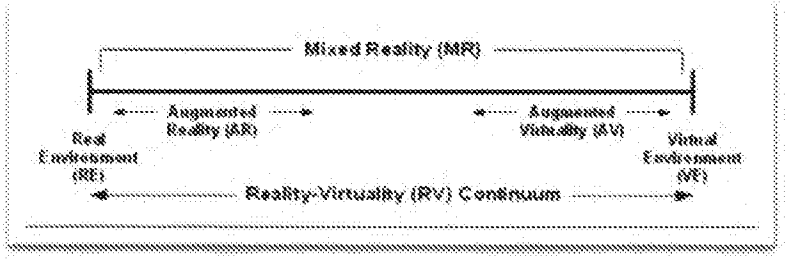
Finally, the evolution of task light into 'robotic task lights' will be covered in the section that will follow in this chapter. To summarize, this review sampled relevant and iconic task light designs. It seems that the task light has invaded our habitat since its invention and it seems it has become a companion to people providing light, design and pleasure of use. It is the design principles and values of the Anglepoise task light that enable us to unfold the design story of LuminAR.

Augmented Reality

Augmented Reality (AR) is a relatively young field, even though its origins can be mapped to early works of Sutherland in the 1960s [23] and Myron Kruger's Videodesk in 1985 [24]. It refers to a set of technologies, which allow computer generated virtual media to overlay physical objects in real time [25]. AR has been the goal of numerous research projects, which tried to create environments that seamlessly blend digital information with the real world.

This thesis work has been inspired and influenced by several excellent research projects that explored interactive systems that blend the physical world with the digital. We review below some of the most relevant prior work, highlighting similarities and differences.

Milgram positioned and classified AR as a subset within the Reality-Virtuality (RV) continuum [26]. He defined Mixed Reality as a taxonomy encompassing both Augmented Reality (AR) and Virtual Reality (AR), juxtaposing between fully virtual and fully real environments.



Reality-Virtuality Continuum (source: Milgram et al 1994; 1999)

Azuma provided a more formal definition of AR as a technology which (1) combines real and virtual, (2) is interactive in real time, and (3) registered in 3D [27].

Bimber and Raskar introduced the term Spatial Augmented Reality (SAR) to describe AR systems that make use of non-traditional display technologies such as digital projectors, holographic displays and

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transparent screens [2]. SAR systems have a clear advantage as they enable an immersive blending of digital media and physical space. This approach also decouples the display from the user, as it does not require the user to wear a head mounted to display or use a hand-held device. However, most SAR systems to date usually lack mobility, due to fixed projector-camera setup. They can also suffer from problem like self-occlusion and ambient lighting conditions [25].

Current Challenges

Augmented Reality as a key user interface technology is still very far from adaption in real-world commercial scenarios. Although advances in computation power and display systems have made great leaps only in the past few years, current commercial experiences are very limited. Advanced AR systems are primarily found in academic and industrial research labs.

The use of Projection-based spatial displays in interactive systems also introduces several new problems [2]:

- A projected display is constrained by size, shape, projector resolution as well as the projection surface color
- Shadow casting of physical objects in the environment
- Sensitivity to ambient light conditions
- Self occlusions by the user can obstruct the projected image and complicate interaction
- Require adaptive and real time geometric projection model

Due to these constraints, most of the interactive AR experiences that were adapted for everyday use normally involve simple single channel I/O via fiducial marker scanning or image recognition. Immersive AR experiences involve custom setup of projector camera systems that require location-specific setup and calibration. Such systems normally require dedicated software to support the interaction. There is no out-of-the-box AR experience except those found in mobile AR products such Layar [28].

We identify three major interaction-limiting factors of existing AR systems: (1) AR is screen bounded (2) Context switch is required to complete the experience (3) The user's hands are not free to interact. We discuss these limitations below.

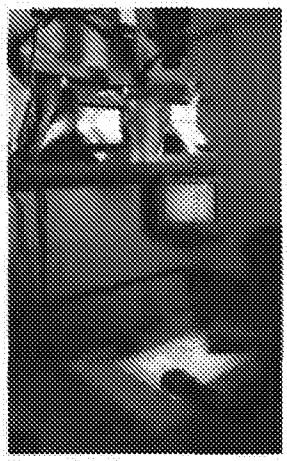
First, current AR interaction is screen-bounded. In order to interact with an AR system, users normally need to actively use a display as a mediator of the actual experience. Screens of various sizes and form factors (e.g. Head-Mounted Displays) are used as the view-port of the AR interface or information.

This leads directly to the second limiting factor: Context switching. Experiencing AR via a display view-port requires users to context switch back and forth between the physical space and the screen used to actually display the augmented scene. This introduces interaction

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discontinuity, and poses challenges to create natural flow in AR applications, not to mention the violation of one of the key HCI principals of consistency.

Finally, the user's hands are not free. Mobile AR systems address some of the issues described above by allowing the user to carry the AR system in his hand; however, they are still suffering from similar interaction limitations. Users normally have to hold onto or wear (e.g. interaction gloves) marker objects in order to interact with the AR interface. Even more critical is the fact that in many cases the user holds the AR interface in one hand using the other hand to interact. Clearly, it is desirable in the case of situated AR to be able to use both hands. Mobile-Wearable systems like the SixthSense [29] device developed at the MIT Media Lab Fluid Interfaces Group, address this problem using a novel wearable form factor and a gestural interface that enables immersive mobile AR.



DigitalDesk by Pierre Wellner

To some extent, wearable AR interfaces (HMD or HUD displays) address these problems directly, however they require the user to adapt by wearing additional computing components, which facilitate the interaction. This work is focused on solving these problems in the indoor domain assuming the user does not need to use any additional hardware.

In the sections that follow, we will focus the related work review in the key domains that provide technical foundations as well as interaction inspiration for LuminAR in light of the current challenges. We will focus the review on augmented interactive spaces, specifically with respect to projected AR techniques, tabletop computing, multi-touch and gestural interfaces. I will also address Kinetic Interfaces and review relevant work in the Personal Robotics domain.

Interactive Spaces

In recent years enabling technologies for the design and implementation of augmented interactive spaces has been extensively researched. Some of the past work includes various computer vision based methods for interaction and augmented reality systems [2], [25].

Augmented Interactive Spaces typically use a projector-camera system along with computer vision techniques to augment a physical space. Wellner's DigitalDesk system is considered one of the first pieces of work in this domain [30-32].

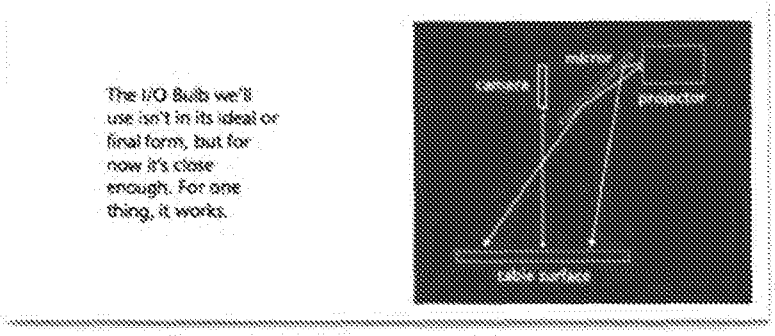
Rekimoto and Saitoh expanded on this approach by introducing wall, table and laptop cross-integration, allowing information to propagate between modalities and devices [33]. The EnhancedDesk [34] introduced real time finger tracking using IR light enabling the integration of paper and digital information.

The LuminAR system enables similar flat surface, desk and table based augmentation and interaction, yet it provides the advantage of portability and compact size, as the entire system is self-contained in

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both the case of the LuminAR Bulb and the LuminAR Lamp form-factors.

Underkoffler et al. in his seminal work I/O Bulb and Luminous room [16], [35], [36] and Urp [37] have described a basic two-way optical information device and how it will be used to transform a room into an architectural information space. At the time, technology and cost issues prevented the full realization of this vision. The actual system implemented included spatially separated camera and projectors. Although a "real" I/O Bulb was described it has to date been unavailable in research labs and as a commercial product.



I/O Bulb and the Luminous room by John Underkoffler (source: [16])

The LuminAR Bulb introduces two major advances over this prior work. First, it realizes the I/O Bulb's vision, and efficiently integrates all the required components for the bulb (camera, computer, projector, sensors etc.) into a single system. It is thus a truly portable and scalable solution to implement customized augmented interaction spaces easily. Second, it adds actuated degrees of freedom, and robotic control elements that enable the LuminAR Bulb to dynamically change projection parameters.

In later work, Pinhanez created the Everywhere Displays [38] that used a stationary projector using a rotating mirror to expand projection to multiple surfaces. He also proposed a portable solution the Everywhere Displays Lite [39]. This work introduced the concept of steerable interfaces that can appear on objects and surfaces anywhere in space, and can also dynamically adapt to form, function and location of the interface as well as user context.

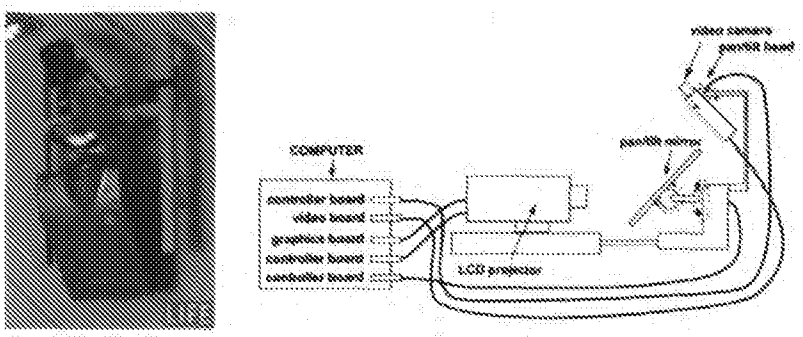
However, even though the mirror element presented in Pinhanez's work offers more flexibility, it allows very limited animatronics compared to the articulated degrees of freedom of the LuminAR Lamp, and it also requires a complex setup. We will elaborate further on the concept of steerable interfaces in the discussion at the end of this chapter.

One of the challenges implementing a steerable and interactive projector camera system lies in the calibration of a generalized optical and mechanical system. Ashdown and Sato presented a method and algorithm for calibrating a steerable projector system, focusing on pan-

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tilt mirror setups [40]. Their work represents an important step, though it is still limited as it is based on the projection of patterns.

Steerable projector systems that use a pan-tilt mirror setup indeed offer more flexibility, but are constrained in terms of calibration and ease of setup. LuminAR address these drawbacks by using a moving projector approach combined with simple one-time offline calibration.

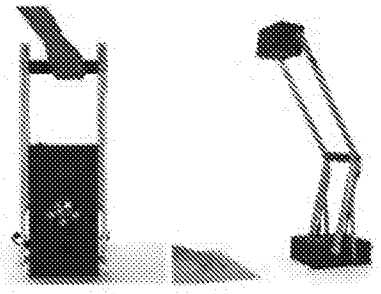


EveryWhere Displays by Claudio Pinhanez et al, work done in IBM Research (source: IBM Research)

In recent years, important advances in portable and small-scale projector camera systems have been realized. Raskar et al. iLamps [41] presented an adaptive projection on non- planar surfaces enabling object augmentation with a hand-held projector, including interaction techniques.

Wilson outlined a more advanced variation on portable projection systems in his project PlayAnywhere [42]. This project explores paper, hand and object recognition using a projection system. The system supports various wall and tabletop use cases.

More recent work has combined pico-projectors and cameras in a lamp form factor. A prominent example is the DockLamp by Kaplan, et al [43]. In addition, Microsoft research has created the Mobile Surface [44] as part of their effort to push forward the domain of Surface Computing. Both pieces of work address both the issue of a smaller form factor and the different hand gestures that will enable users to interact with augmented reality interface.

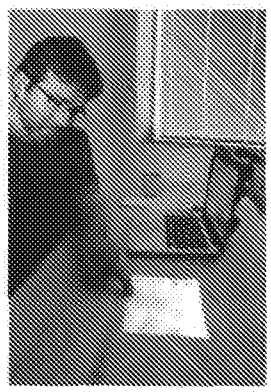


DockLamp by Frederic Kaplan et al

Even though these examples demonstrate substantial, yet incremental improvements in portable AR interfaces, unfortunately all of the systems described above are completely static once they are installed in a space. This fact limits the scope of interaction and augmentation experience these systems can provide. The LuminAR Bulb and Lamp's robotic capabilities address this limitation directly.

Projects like DeskJockey [45] and Bonfire [46] have introduced PC-centric workspace extension using projection. DeskJockey used a fixed projector to superimpose widgets in the space around a PC. Interactions were possible via proxy window on the PC desktop only. The Bonfire project suggested another approach, presenting a nomadic projection system attached to a laptop using two pico-projectors. In

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Bonfire by Shaun Kane et al developed in collaboration with Intel Lab (source: Intel Labs)

contrast, the LuminAR approach does not require or assume a PC to augment a space and it is not dedicated to PC based interaction. The LuminAR system has a dedicated computer that allows it to remain portable and to easily interface to different displays in its vicinity.

Prior research in augmented interactive surfaces has extended surface based interactions to more elaborate object-based physical/digital interactions. Systems like metaDesk [47], WeSpace [48], UbiTable [49] and MemTable [50] introduced object based interactions to retrieve documents or interact with the projection surface. These systems typically use fiducial markers, RFID or other wireless mediums (e.g. Bluetooth, Sigsbee etc.) to register object in the system. LuminAR is designed to support both marker and marker-less object registration and recognition. This approach yields an enhanced user experience, as shown in recent work like the OASIS project from Intel Research Lab [51]. OASIS introduces a framework for general-purpose object recognition for interactive systems. The framework is integrated with a projected display to create interactive "islands" in everyday environments.

Multi-touch and Gestural Interfaces

Multi-touch and gestural interfaces provide the foundations of interaction techniques this work presents. One of the earliest visions of gesture base interfaces was introduced in the StarFire video prototype [52]. Early gestural interfaces systems employ simple computer-vision based freehand-gesture recognition techniques [53-55].

In the past decade, the domain of gestural and multi-touch interfaces has been extensively researched. The key element of such systems is the implementation of robust touch detection mechanisms that allow direct manipulation of data using natural gestures [56-58]. Buxton provided an excellent summary of such systems in [59]. Multi-touch systems use a large variety of sensing technologies. The most common of them include: (1) Periphery, front or back mounted camera using custom surface as a display and interaction surface [60-62] (2) IR Cameras [53], [63] and multiple (stereo-vision) cameras [54], [64] (3) Embedded capacitive or resistive sensors [56], [58] and (4) Acoustic sensors [65].

The fundamental drawback of such multi-touch systems is that they are only able to detect physical touch events, and therefore incapable of supporting touch independent freehand gestures or to detect arbitrary objects. They also involve a non-trivial setup of several independent components (i.e. computers, projectors, mirrors etc.) that complicates deployment, and in most cases they require users to perform manual calibration steps. Current gesture recognition systems discussed below, unfortunately still suffers from similar limitations. Our approach uses computer vision techniques to create a system that supports both touch interactions as well as gesture recognition in a portable form factor, addressing many of the drawbacks described above.

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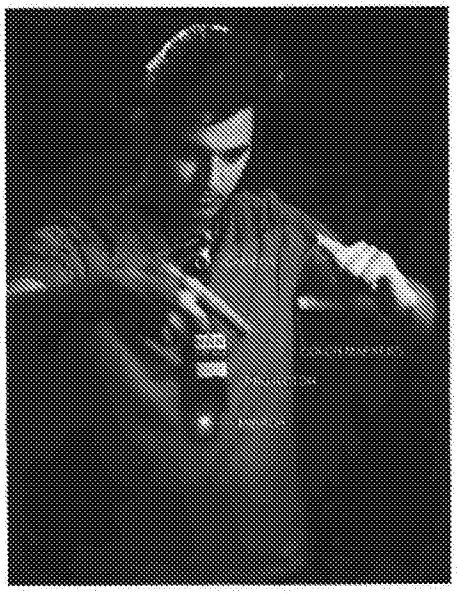
In recent years, various advanced gesture interaction paradigms have been explored including hand gestures [66-68]. Additional examples include the HoloWall [60] project and Oblong's g-speak system [69]



Oblong G-Speak System (source: Oblong Industries)

Continuing advances in miniaturization of projection technology, embedded computing and computer vision algorithms enabled several portable, mobile and wearable gestural interfaces systems in the past few years. Examples of such systems include the SixthSense device [29], [70], the iLamps project [41], and additional examples are [71-74].

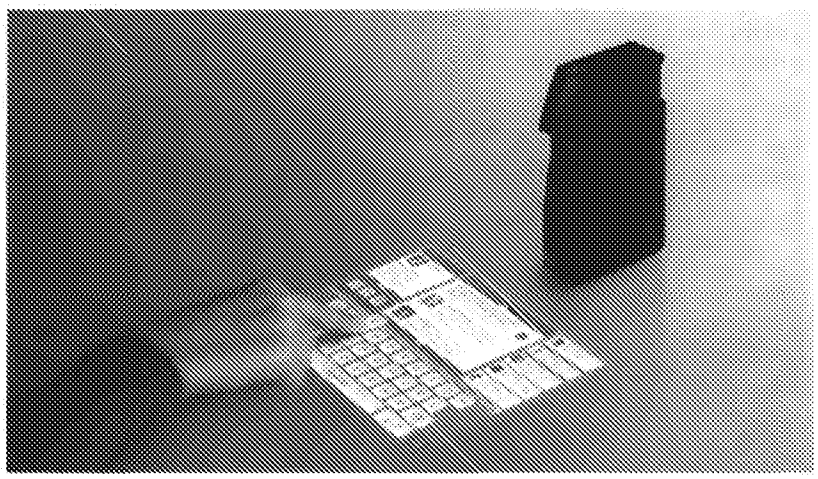
These systems generally involve a user who either wears or holds a projector, using it to augment a surface or an object. Our work is distinct from the handheld gestural interfaces as it leaves the user's hands free to interact. It is also distinct from wearable systems, as it does not require the user to wear anything in order to interact with the system. Since LuminAR is a situated AR system, our work emphasizes portability over mobility. By "portability", we refer to the ability to simply unplug the system and move it to a different location, without the need for a complex setup or further calibration.



SixthSense device by Pranav Mistry and Pattie Maes (source: MIT Media Lab)

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Finally, in 2010, Light Blue Optics a UK based projection systems start up, introduced Light Touch [75] a portable, interactive laser pico-projector platform that is capable of projecting a virtual touch screen.



Light Touch by Light Blue Optics

Kinetic and Robotic Interfaces

The field of personal robotics has advanced at a fast pace since the introduction of microcontrollers. Domestic robots have become a commercial reality in areas such as companion toy robots such as Sony's AIBO and Innovo Labs' Pleo [76], [77], service robots such as the Roomba and Scooba from iRobot [78], personal surveillance and security [79]. Social robots that serve as robotic coaches have also recently emerged from the labs [80].



(a) (b) (c) (d) (e)

Personal Robotics: (a) Innovo Labs Pleo (b) Sony Aibo (c) WooWee Rovio (d) Intuitive Automata Autom (e) iRobot Roomba (image sources from respective companies)

However personal robots designed as 'information interactive robots' are still in a very embryonic stage. It is clear that the future will make more use of AR techniques to facilitate a more expressive interface for robots themselves. Green et al. detailed the case for AR enabled robots in a comprehensive review [81], [82]. We are interested in using robotic capabilities to enhance interactive information driven application. This work explores the design of such robots and their use in real-world scenarios.

Recent projects explore different aspects of human-robot interaction (HRI). Specifically, they explore robotic form factors for personal

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computing. Examples of such projects include RoCo [83] which is considered the first robotic computer. RoCo was designed with the ability to move its monitor in subtly expressive ways that respond to and encourage its user's own postural movement. RoCo was mainly used as an HRI research platform and did not address the requirements of supporting an augmented reality interface.



(a) (b)

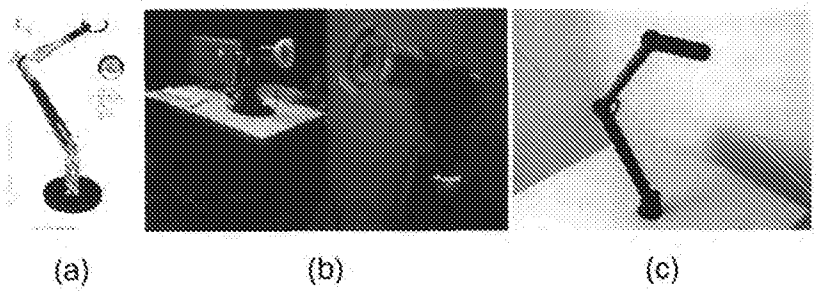
Kinetic/robotic interfaces: (a) RoCo by Breazeal et al (b) OZWE QB1 Robot – a computer with social skills (source: MIT Media Lab, OZWE)

Another example is the QB1 Robot [84], which is a social robot that learns about its user and offers an expressive, animatronics interface to different media applications. QB1 also utilizes a gestural interface. However, QB1, like RoCo, uses computer-screens as its display medium. This limits substantially their ability to augment their environment. Our approach integrates an actuated robotic arm and a projected display into a single system. We believe this approach will offer better support for interactive scenarios.

Besselink et al. created the first robotic lamp the author is aware of in 1991 [85]. Their lamp robot was developed for future scenarios for home use. They also suggested applications for handicapped users. They also proposed a unique memory-metal actuation technique, and integrated speech recognition for user interaction.

Hoffman created - a robotic desk lamp, which acts as a collaborative lighting assistant [21]. AUR was used to explore the concept of fluency in human-robot collaboration. Finally, Stubbs and Lerner, created Outerspace Robot [86], a reactive robotic creature designed to explore the surrounding space and interact with people through touch and behaviors. These projects are good examples of robotic arms that are specifically designed for human interaction, but they are very limited in digital media interaction capabilities, as they have no display and very little spatial sensing.

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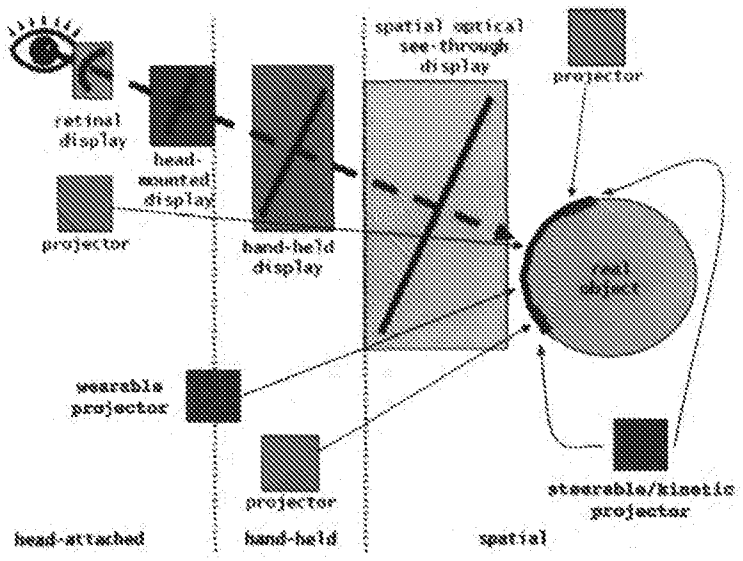
(a) (b) (c)

(a) Besselink et. al. Robotic Lamp (b) Hoffman's AUR (c) Stubbe and Lerner Outerspace Robot (source: J. Phys. IV France, MIT Media Lab, A. Stubbe)

Projected Augmented Reality Interfaces Classification

For the purpose of this thesis, and in light of the abundant work in the domain of augmented reality, it is important to position the LuminAR work within the context of the previous work. Several surveys also classify and analyze different technical aspects of the actual display and sensing sub-systems, and we refer the readers to the latest survey by D.W.F. van Krevelen and R. Poelman [87] for further reading.

Bimber and Raskar [2] classified the approaches to augmented reality displays technologies into head-attached, hand-held, and spatial displays.



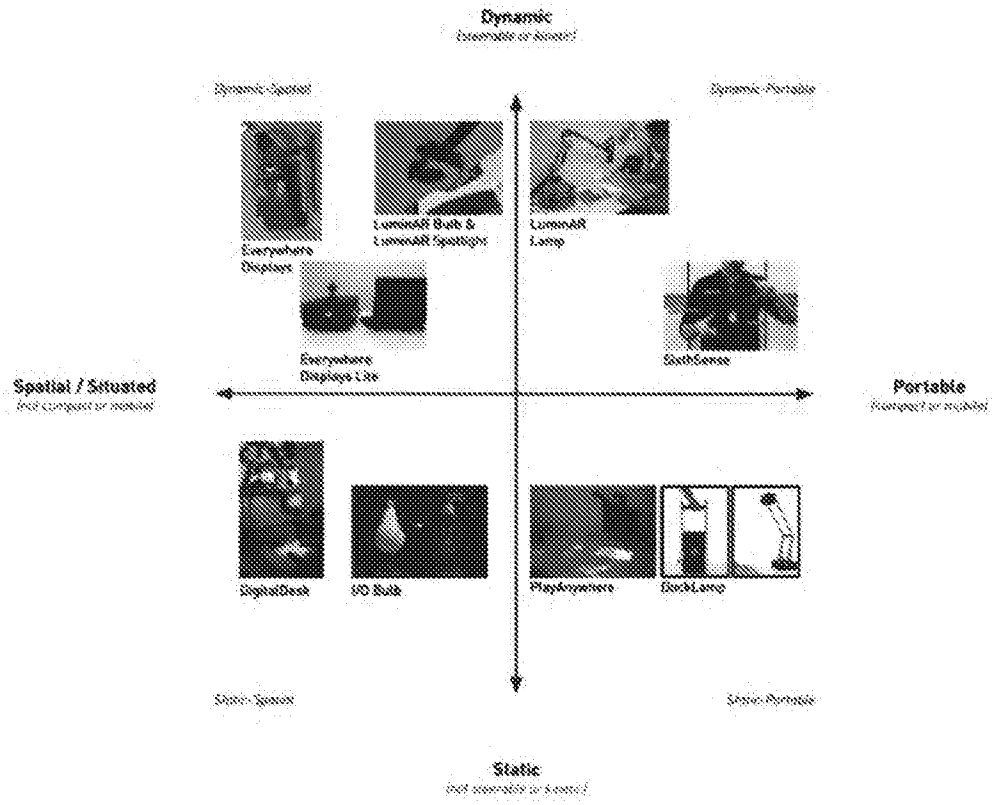
Positioning wearable projectors and steerable/kinetic projector system in the context of Spatial Augmented Reality, we have updated the original diagram by Bimber and Raskar to include the cases of wearable projector and steerable/spatial projector in blue. (source: Oliver Bimber and Ramesh Raskar)

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They also proposed the diagram below to summarize this categorization. We have added to their classification two additional cases that complement the definition of spatial augmented reality displays with new approaches that were reported since their work was published: (1) wearable projector, and (2) steerable/kinetic projector.

Finally, we define kinetic projectors as a subset of steerable projectors. The key difference being the fact that kinetic projectors have their own actuated degrees of freedom of the actual projection source. According to these definitions, LuminAR devices can be classified as kinetic projection-based spatial displays.

To visualize the unique positioning of LuminAR as a new class of augmented reality interface, we created a Projected Augmented Reality Interfaces Classification quadrant diagram. We use a semiotic square relationship that juxtaposes two sets of properties that define our system: (1) steerable/kinetic vs. static and (2) portable vs. not spatial/situated.



Projected Augmented Reality Interfaces Classification

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Using this diagram we can roughly define four distinct categories of projected augmented reality interfaces:

- ***Static-spatial:*** non-steerable or kinetic systems that are permanently installed in a space. Interaction is commonly constrained to a predefined and fixed space. Examples of such systems are: [16], [32]
- ***Static-portable:*** compact non-steerable or kinetic systems that can be relatively easily relocated from one space to another, commonly support automatic calibration. Examples of such systems are: [42], [43]
- ***Dynamic-spatial:*** steerable or kinetic systems that are statically installed in a space. Examples of such systems are the Everywhere Display [38], [39] as well as the LuminAR Spotlight
- ***Dynamic-portable***: compact steerable or kinetic systems that can be easily relocated. LuminAR lamp is the only example of such system we are aware of. We can also consider the SixthSense device [29] to be a dynamic-portable system, as it is a wearable system that adapts to the user viewpoint

Characteristics of Steerable and Kinetic Systems

Pingali et al's groundbreaking work on steerable interfaces [88] presented an alternate approach for pervasive computing interfaces. In their vision, interfaces to computing should appear where and when the user needs it, and when ever he needs it. They outlined the salient characteristics of such steerable interfaces:

- ***Support moveable input and out output:*** interactive interface that can move around the physical environment and appear on ordinary objects or surfaces.
- ***Adaptation to user context:*** interface should respond to some sensing of user needs based on location, physical function or other data. Freeing the user from a single point access to a computer with a traditional mouse and keyboard interaction
- ***Adaptation to environmental context:*** interfaces that adapt to the characteristics of the environment and change accordingly in terms, of location, size, shape color etc. This normally means that the system should be aware of the geometric and ambient parameters of the physical space.
- ***Device Free and Natural Interaction:*** steerable interface is able to sense and support forms of interaction such as speech, hand gestures, motion of body, touch etc. which are based on the human body and do not require special devices.

Through this thesis work, and the design of the LuminAR form factors we can propose new characteristics to complement the set above and

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possibly drive forward the adaptation and investigation of steerable and kinetic projected augmented reality interfaces:

- ***System portability:*** Users should be able to reconfigure and change their environment. Projected augmented reality systems should be designed to be compact and simple, such that a user may decide and easily relocate the system in a physical space. To achieve such portability it is important to design compact systems, which support automatic calibration of the projected display. It is also required that such systems are able to sense and map the environment to support interaction
- ***Embedding computation in everyday objects:*** Closely related to the need for high portability is the need to design pervasive interfaces that disappear into the physical environment. To achieve that it is required to design computation functionality into everyday objects that already exist. Examples are desks, lamps and light bulbs
- ***Integrating User Interface Modalities:*** projected kinematic interfaces should be designed to support multiple user interface modalities that utilize traditional multi-touch combined with hand gestures and object manipulation. Users should be able to seamlessly and naturally mix all modalities
- ***Using Physical Motion:*** physical motion can greatly enhance interfaces, as humans are responsive to kinesthetic sensations. It is possibly to create a richer user interface that uses motion cues as part of the interface feedback loop. Further more, actuation and animatronics sequences can be used to direct a user or even embody information

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3 LuminAR

The LuminAR prototypes were developed through several design and implementation iterations, aiming to push the technical boundaries of existing augmented reality interfaces, but also to break new ground in terms of the industrial design of new form factors.

In this chapter we describe the technical implementation details for the family of LuminAR devices we have designed and developed in course of this thesis work. We begin with discussing the design principles LuminAR devices share, and continue to describe each of the prototype systems we have built. We begin with the heart of the system - the LuminAR Bulb. We then discuss the prototypes of the LuminAR Lamps, which are comprised of specifically designed robotic arms that carry the LuminAR Bulb. Finally, we discuss the LuminAR Spotlight device prototypes.

For each of the different systems, we provide technical details of the hardware we developed, and discuss relevant industrial design considerations. We conclude this chapter with an overview of the LuminAR LuXor software framework that is shared across the devices.

While this chapter focuses on the technical details and physical design aspects of the LuminAR devices, it sets the ground for the next chapter, which deals with the interaction techniques LuminAR enables. The two chapters are closely related, and together they form a complete description of the design goals and the implementation. Finally, we also refer the readers to the appendix where we included a fairly complete mechanical specification for the various LuminAR devices described in this chapter.

Design Principles

In chapter 2, we presented and discussed the properties of steerable and kinetic interfaces. This background research was the driving force for the LuminAR design, resulting in a novel compact and kinetic projected augmented reality interface. In this section we describe the common design principles that guided our work.

Simple everyday objects that hide technology

Hide computation and interfaces in familiar devices, which have common, everyday form-factor. The forms LuminAR devices take on today are those of a light bulb, an Anglepoise task light and a track light fixture. From a user's perspective these objects should obfuscate the underlying technology they use. At the same time, when used, they provide known affordances and almost natural, contextual interaction techniques, using hand gestures, multi-touch and kinesthetic (we delve into the details of LuminAR's interaction design principles in chapter 4).

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Portable, compact and self-calibrating

Design compact and portable devices, which are capable of dynamically forming an interaction space. A non-technical user can easily relocate a LuminAR device from one place to another. The system should function without the need for any prior knowledge of the space it is deployed in. This dictates the use of simple power and data interfaces, but also the need to support automatic calibration of the AR subsystem.

Embedded, connected and modular

Directly derived from the need for portability, is the need for the LuminAR devices to be self contained computing systems. This dictates the design of the LuminAR bulb, the heart of the each LuminAR device as a wireless embedded computer with all required peripheral interfaces for display, actuation and sensing.

The LuminAR bulb can connect to a network connection. The network can provide content, interfaces and facilitate data exchange with other LuminAR devices. It also allows LuminAR devices with modularity, in two key aspects: (1) off-loading computation to remote devices or other network services, and (2) supporting interaction scenarios where two or more LuminAR devices are used in parallel.

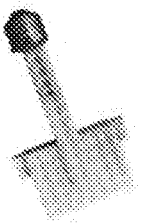
Kinetics

The ability to move makes interfaces dynamic (i.e. not statically situated in space). This principle is juxtaposed with existing display centric devices that by definition are static once positioned within a workspace. LuminAR devices can dynamically reposition a projected interactive display. They can also use motion to enhance user interaction.

Design for product

Product design balances the need for functionality and aesthetics. As one of the goals of this thesis work was to push the boundaries of current computer form factors, product design methodologies played a key role. We considered issues that go beyond a pure interaction research agenda, and considered core product design issues such as ergonomics, safety, standards, heat dissipation and work envelopes.

Product design also assumes that prototypes mature and down the road manufactured. This is the reason we tried, as much as possible, to use existing, off-the-shelf available technologies. We selected components that can be mass-produced, making LuminAR devices low cost and commercially viable.

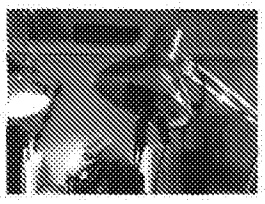


The bulb's LEGO bricks mockup model

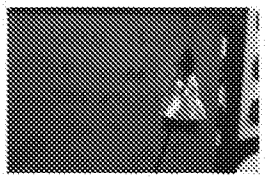
LuminAR Bulb

The LuminAR Bulb is compact, kinetic and interactive projector-sensor system. The system is designed to follow the physical metaphor and

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Testing of early version of the bulb in a Luxo Lamp



Overnight weight testing the bulb in a snap on spotlight lampshade

design language of a classic light bulb, evolving it to an interactive computing device.

In chapter 2, we provided an overview the design space of light bulbs. While trying to adhere to the dogma of bulbs that fit into a standard power distribution grid, we were also inspired by the conceptual underpinning Underkoffler provided in his work on I/O Bulb [16]. Recent advances in technology provided additional motivation, and ten years after the I/O bulb publication, this thesis attempts to fully realize the vision of the I/O bulb within the design parameters of an actual light bulb.

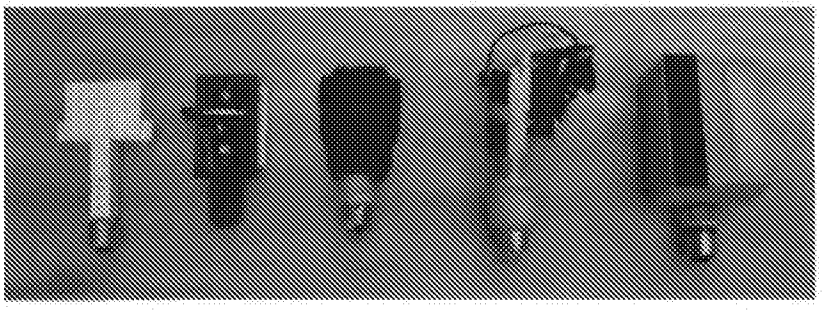
Design Goals

With this general goal in mind, we also had concrete design goals that guided the design work of the LuminAR Bulb:

- Create a fully realized two-way information device, which requires only AC power and wireless communication to operate.
- Design the bulb to fit in standard Edison bulb sockets.
- The bulb should be compact and completely self-contained projector-sensor system. It should integrate a laser pico-projector, cameras, sensors, control electronics, power supply and an embedded wireless computer.
- The bulb should have its own DOFs for pivot rotation, and camera tilt.

Design Process

The design and development involved several iterations. Initial exploration of form and fit to light fixtures were constructed from LEGO bricks, but we quickly moved on to advanced materials in the prototype that followed. The shape and weight of the bulb were critical factors to observe, as we tried to integrate together several components. Fitting the bulb in standard fixtures and lampshades dictated our general circumference and a weight constrains. To explore physical constraints we created a set of conceptual prototypes.



Early mock up models and conceptual prototypes of the LuminAR Bulb

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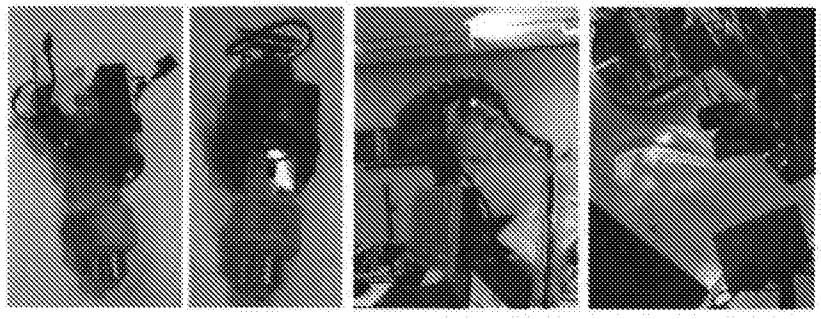
As our work progressed we were able to refine the design and consider different packaging strategies. We go into the details in the sections that follow. We focus our discussion on the latest and most relevant iterations of the LuminAR Bulb.

Early Versions – Make it work!

Our first version of the LuminAR Bulb was very much a learning prototype and had limited functionality. Based on our initial mock-ups, we designed a frame to carry a pico-projector and a webcam. The frame was also fitted with a standard male Edison screw using a hacked bulb screw adapter. At the base of the frame we constructed a stationary double disc part. The stationary part was glued to the screw cavity, providing support and pivot-axis rotation. The rotation axis was not actuated, but we could manually set the radial position of the bulb.

This bulb's frame was constructed from laser-cut acrylic parts that were press fitted and glued. The frame was designed to support the adjustment of the projector plane and camera plane individually. This was done to allow us to experiment with different hardware calibration parameters for the computer vision software.

However, This version of the bulb did not include any power circuitry, and we used external power cables to supply the bulb.



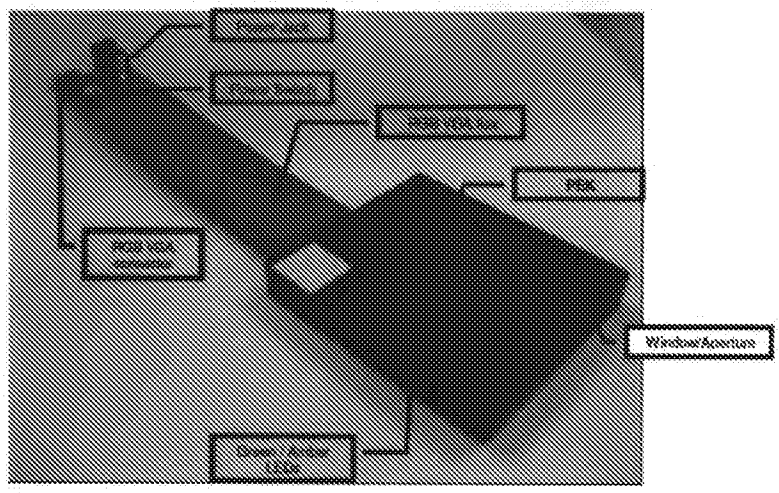
LuminAR Bulb early versions. Bulbs are fitted with Microvision PEK-1 laser pico-projector with a custom heat sink

We selected the Microvision's PicoP™ Evaluation Kit v1 (PEK-1) as our projection engine. The PEK-1 served as excellent prototyping platform. It has standard VGA display interface, a thin profile and small mechanical dimensions (H 10mm x W 61 mm x L 68mm). It also uses 5V power supply.

The main advantage the PEK-1 has is that it is a full color laser projection device. It provides a resolution of 848x480 (WVGA) with 16bit color depth and 16:9 aspect ratio. It has a focal range between 200mm-2000mm; in this range the image is always in focus, ideal for a dynamic kinetic platform like LuminAR. In addition our version of the PEK-1 was upgraded to Class 3R Laser device, outputting 15 lumens, which was bright enough for many of applications even in bright daylight conditions.

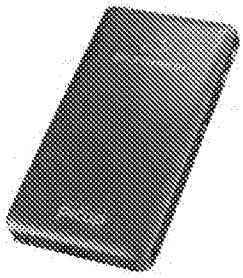
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The PEK-1 has to be fitted with a heat sink element for ongoing operation. To conserve the bulb's small footprint, we replaced the PEK-1 original heat sink that extended the PEK's mechanical dimensions with our own compact design. Our heat sink was designed to fit the PEK-1 enclosure. It was fabricated from three 0.125" aluminum sheets with 11 ribs of approximately 0.1" inch wide.



Microvision's PicoP™ Evaluation Kit v1 (PEK-1)
(source: Microvision)

Since we only had one PEK-1 unit, in some iterations, and for prototyping purposes we also used Microvision's SHOW-WX Laser Pico Projector, which has similar specifications, except for a low power laser – Class 2, which makes it a bit less bright.



Microvision SHOW-WX Pico Projector
(source: Microvision)

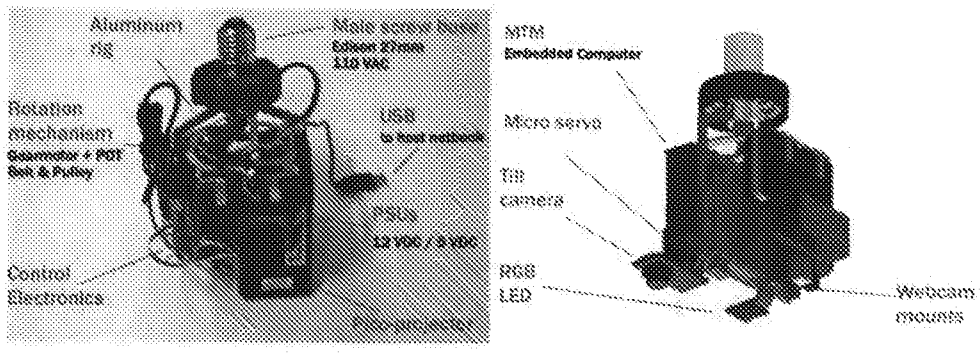
We used a micro R/C servo fitted with a custom made horn to provide support for the webcam. We selected the Microsoft LifeCam NX 2000 webcam, mainly as it has a very small footprint for both the optics and the electronics, but also as it was relatively inexpensive to the quality of the images it provided (2 megapixel).

LuminAR Bulb version 1 was mainly used in fixed light fixtures to facilitate software development, but was also the main bulb we used for the LuminAR Lamps Optimus and Aluminum models we describe later in this chapter.

Integrating subsystems

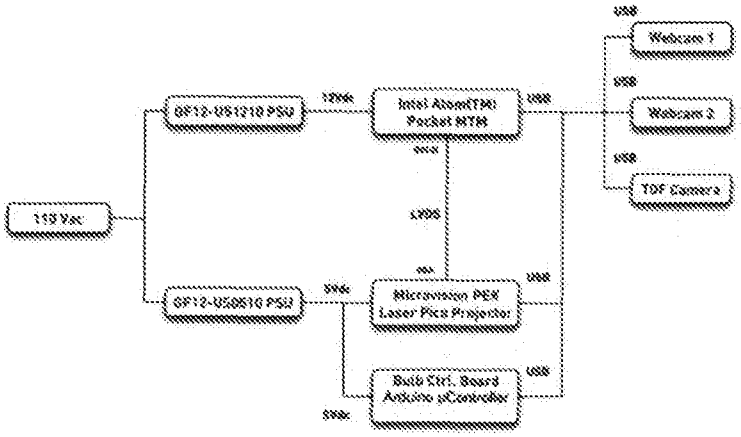
The following two LuminAR Bulb iterations, focused on subsystem integration. With the goal to develop a fully functional prototype, design details were intentionally left for later revisions.

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LuminAR Bulb integration version: on the right we show a view of the CAD design and on the left we show the physical prototype.

The block diagram below shows a general overview of the bulb's components and their respective connections.

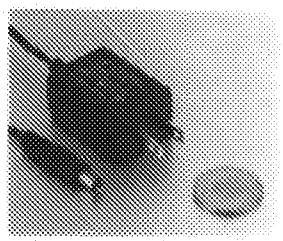


LuminAR Bulb power and connections schematics

Power Circuitry

The bulb was designed for use with standard Edison sockets. To accomplish this, we had to incorporate AC/DC switching power supply units internally. The pico-projector and control electronics were supplied using a 5V/2A line. To support the embedded computer we need a 12V/1A line. USB peripherals were fed 5V directly from the USB lines.

To maintain the bulb's limited space constraints we selected two small 5V and 12V PSU package from Go Forward GF 12 series (GF12-US0510 and GF12-US1210 respectively). The GF12 series were ideal, with mechanical dimensions of: LxWxH:45.4x33.3x24.7 (mm).



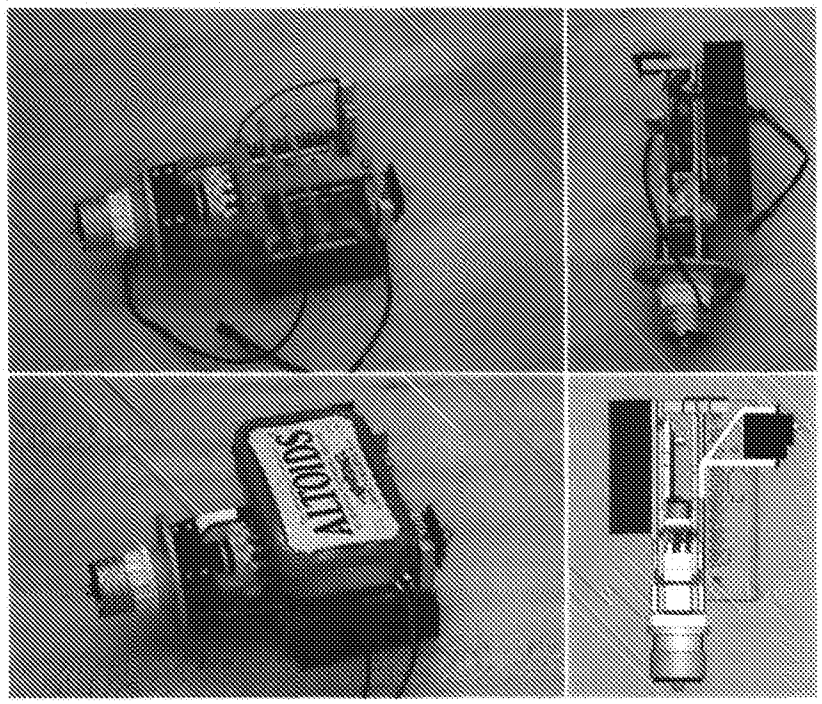
Go Forward GF 12 series PSU (source: Go Forward)

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Integration into the bulb included hacking the units, eliminating the original wall plug and jack connectors, leaving only the plastic case, a power and ground wires. Keeping the PSUs plastic case also helped deal with the heat dissipation.

Lightweight aluminum rig

First, to support a complex integration of electronics, motors, cables and components (i.e. webcam, embedded computer etc.), we had to design a light yet strong rig that would be able to mount all the components in place, and provide us with a platform to test different configurations. The rig was constructed from 0.125 aluminum sheets. The use of aluminum also allowed the frame to serve as an additional heat sink. On one side of the rig we attached the PEK-1, and the other side was reserved for an embedded computer.



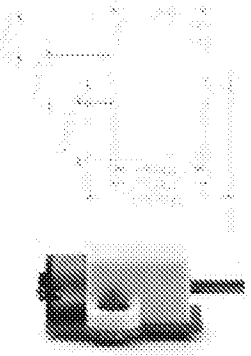
LuminAR Bulb integration version lightweight aluminum rig. This sequence shows on of the earlier designs, the Altoids box serves as a placeholder for the MTM Atom embedded computer. This rotation mechanism in this version used a central shaft solution.

Rotation Mechanism

The top section of the rig was used to house a rotation mechanism, which was coupled to the male Edison #27 bulb screw interface. The shaft is rigidly fixed to the screw through a flange. Managing the bulb mass and cabling made supporting pivot-axis rotation a difficult task. We tested two alternatives for the rotation mechanism.

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Our initial approach used a central shaft coupled to a micro gearmotor mounted on the rigs' top section. We used Pololu Micro Metal gearmotor, which is extremely small and efficient, thus ideal for use in embedded systems. The motor ran at 5V with a gear ratio of 250:1, capable of an approximate torque of 4kg-cm. The motor was also coupled with a wheel optical encoder. The plastic ribbed wheel was designed to generate reading for the phototransistors on the encoder board. The encoder board was attached to the motor using a custom plastic bracket. The encoder was running at 5V providing 48 counts per revolution, a linear resolution of approximately 3 mm.



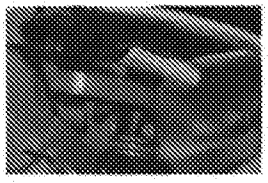
Pololu micro gearmotor and encoder board

This initial approach did not prove mechanically robust enough over continuous runs. Moreover, sensing the bulb's position proved challenging using the wheel encoder. However, the biggest hurdle was the size of the wheel encoder. This led us to replace both the rotation and the sensing mechanisms.

In our second approach, the rotational motion is generated by the same gearmotor and transmitted through a belt drive. The bulb's structure rotates below the belt around the central shaft. We selected a shaftless potentiometer mounted directly on the main shaft.

Control, Electronics and Firmware

The bulb's electrical systems were designed to digitally control the rotation mechanism, sensing, LEDs and additional servomotors. To accomplish this, we programmed a small microcontroller system (Arduino Pro Mini 328 - 5V/16MHz) to interface with a small and commercially available motor driver board (Pololu Qik 2s9v1 Dual Serial Motor Controller). The board provided us with means to control the motor's speed and direction. The rotation motion was monitored using a closed loop, continuously reading the potentiometer position. The feedback loop provided relative accurate positioning in a range close to 350 degrees (taking into account the potentiometer dead zone).



Belt and Pulley mechanism prototype

Micro servomotors (Power HD Sub-Micro Digital Servo DS65HB) that were used to carry the additional webcam, were interfaced directly to the microcontroller and were controlled using standard PWM signals. We also used the same microcontroller to interface to an RGB LED (ShiftBrite RGB LED).

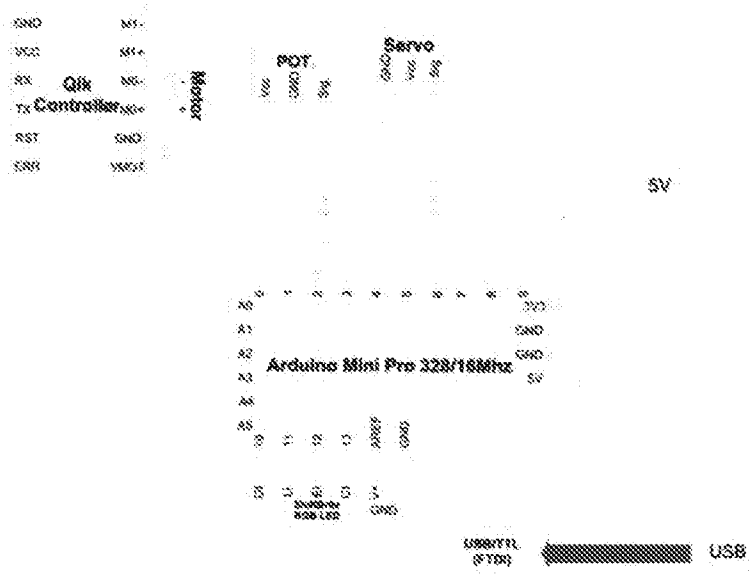


Panasonic shaftless potentiometer (source: Panasonic)

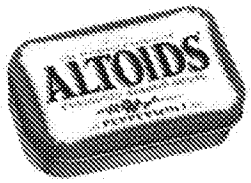
The bulb's firmware provided simple interfaces to control the bulb orientation and query its encoder position. This interface was used by LuminAR application to define user interface projection orientation.

The bulb's host computer, using RS-232 serial communication over an FTDI USB connection, controlled the bulb's board. The diagram below shows the bulb's electrical schematics. This design was also used for future version but actual layout was changed to fit the physical dimensions of the new design.

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LuminAR Bulb control electronics board schematics

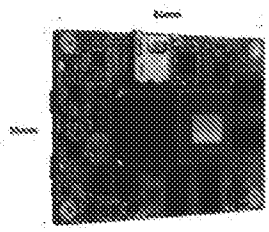


MTM was designed to be slightly bigger than an Altoids box
(source: Altoids)

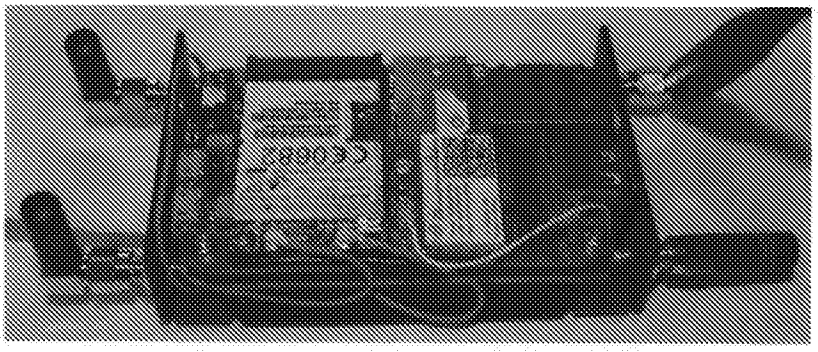
Embedded Computer

The bulb's embedded computer was a pre-release version of Intel's Machine-to-Machine (M2M) reference platform [89] based on the Atom™ Processor.

The M2M is comprised of a carrier board and a Kontron COM Express* compatible nanoETXexpress-TT Computer-On-Module. The system is packaged in an enclosure that measures 100 mm x 67 mm, slightly larger than an Altoids box, making it ideal for a space constrained hardware like the LuminAR Bulb.



Kontron COM Express* compatible nanoETXexpress-TT Computer-On-Module.
(source: Kontron)



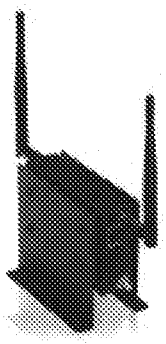
Intel Atom MTM platform

The M2M supports wireless connectivity, including WiFi, and optionally additional radios (e.g. Bluetooth, ZigBee or 3G/4G). It also has an accelerometer, dual HDMI display ports, HD audio, GB Ethernet and 3x USB ports. The nanoETXexpress can carry fanless dual-core Atom Processors that run at 1.6Mhz. The system has 1 GM of memory and

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an external MicroSD card that can support upto 32 GB of storage. These specs enabled us to run the LuminAR software stack and perform computationally intensive tasks such as real-time control, computer vision as well as communication and graphics rendering.

Unfortunately even though our design takes into account key embedded system engineering issues such as heat dissipation, connectors, and mechanical mounting, we stumbled on a major roadblock in the final integration step. The MTM display adapter and the Microvision PEK display input were incompatible. The PEK expected an analog VGA input, while the MTM output was digital signal DVI-S. At the time this thesis work had to complete, we decided not to invest in developing our own convertor, and off-the-shelf convertors were simply too big for our design. However, we are aware that future display adapter formats (e.g. DisplayPort) can solve this issue in the future.



Intel Atom MTM
(source: Intel)

Our intermediate solution for development and demo purposes was to use Atom based netbooks. We selected Asus Eee PC 1015PN and Eee PC 1215N both Atom based and with very similar specifications to the MTM. The constraint of having the actual computer external to the bulb mandate additional complexity when managing VGA and USB cables, which was particularly challenging in our final revisions.

Webcams

The bottom part of the rig was designed to carry a stationary webcam, and tilt web cam. The stationary webcam was aligned to the pico-projector aperture. Since the positions of the projector and the webcam were statically fixed with respect to each other, we could support easy semi-automatic calibration when installing the bulb in different locations.

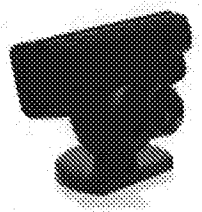


Microsoft LifeCam NX-6000 was hacked to serve as the bulb's tilt webcam
(source: Microsoft)

The tilt camera was mounted on a small micro-servo and was positioned to serve both for interaction purposes, but also to capture the users face or objects in the workspace. With a range of motion of approximately 90 degrees, the camera could be positioned down vertically to view the tabletop, of horizontally to view the space in front of the bulb.

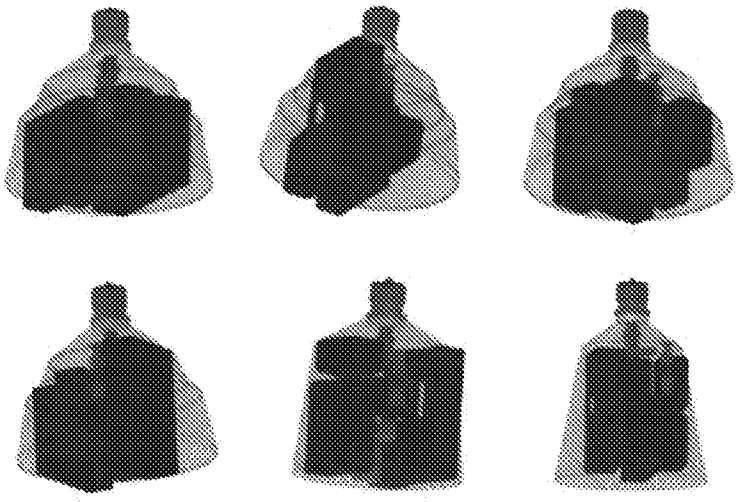
Physical configurations

We explored several different options for the bulb's component integration configurations. We tried to come up with different designs that would make the bulb feasible to use in different light fixtures. The domain of light bulb design is highly standardized, and we refer the reader to [90] for more information. We include some of our design configuration evolution in the figure below.



Sony Playstation 3 Eye Camera was hacked to serve as the bulb's stationary webcam
(source: Sony)

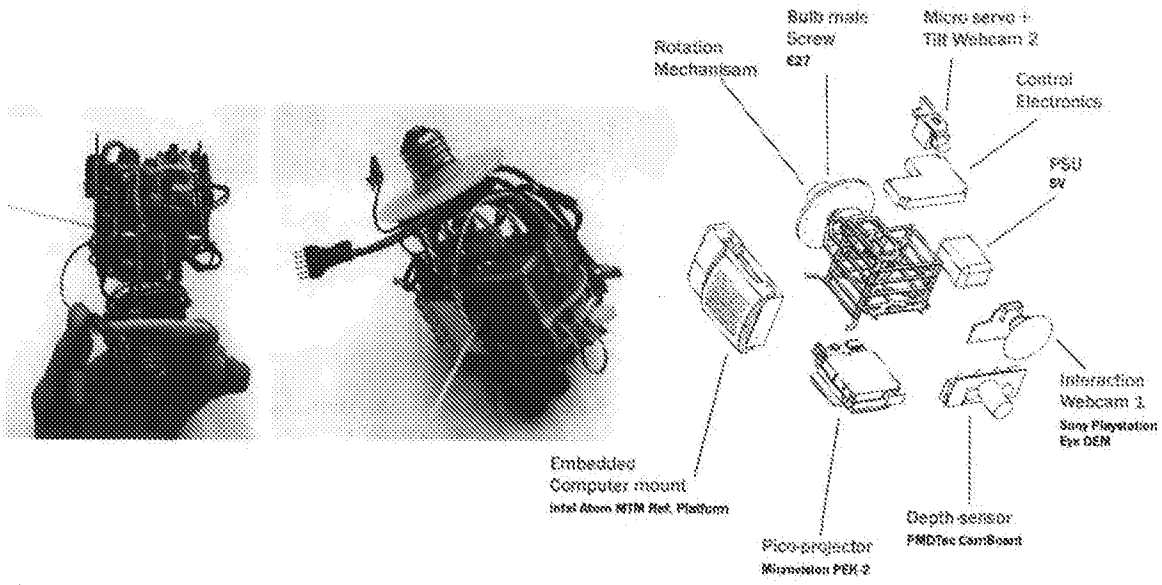
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Exploring physical configurations for the bulb

Final version - compact design and packaging

The final bulb iteration focused on compacting and streamlining the design and packaging the bulb in product-like covers. Based on our previous integration iteration, we were able to reduce the bulb size by approximately 30% without its covers.



Luminar Bulb – final version

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Improved rig, electronics and cable management

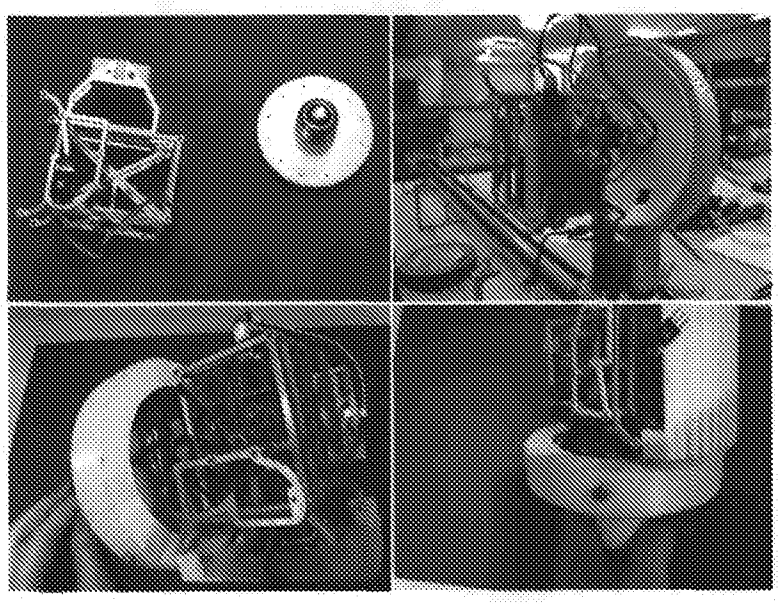
The rig of the final version was made of 1/16" Aluminum sheets. The design follows a layered approach. Spacers separate each layer of the frame. The electronics board design was improved to fit internally in one of the bulb's frame layer.



Microvision PEK2 laser pico-projector

The rotation mechanism was also redesigned for additional robustness. The shaft was reinforced with a collar. The pulley was also reinforced with additional trust bearing to handle radial load.

Cable management posed an additional challenge, as we aimed support close to 360 degrees of rotation of the bulb. To accomplish this, we designed a cavity in the top section of the bulb, under the E27 screw that allowed the cables to rotate freely around bulb's main shaft.



The LuminAR Bulb final lightweight aluminum rig design. The rig allowed efficient component mounting. It also took into account the need for efficient cable management. Cables were coiled in a special cavity created above the rotation mechanism, directly below the Edison bulb socket interface.

Even smaller projector

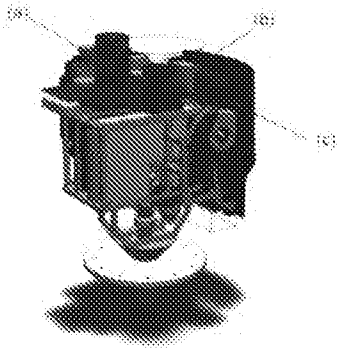
The final version of the bulb was designed to use Microvision's PicoP™ Evaluation Kit v2 (PEK-2) Laser pico-projector. The PEK-2 replaces the PEK-1 kit we in the earlier versions. It's main advantage is its extremely small mechanical dimensions, of W x L x H 55mm x 68 mm x 21 mm. It also has a simpler display adapter interface with no additional Flex cable.

Adding webcams and sensors and putting it all together

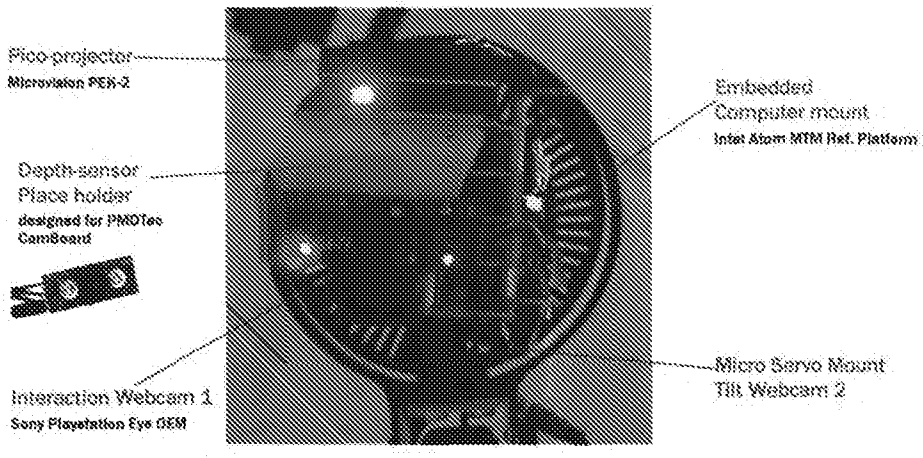
On the bottom section of the rig we mounted webcams and sensors.

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Sensor	Manufacturer/Model	Description/Purpose
Interaction Webcam 1	Sony Playstation Eye (PS3) OEM	A stationary webcam, aligned to the pico-projector aperture. Used to capture interaction gestures, capture imagery and detect fiducials.
Tilt Webcam 2	Microsoft LifeCam NX-6000	A rotating webcam, mounted on a servo. Designed to swivel 90 degrees between a position looking down, and a front facing position. This camera can be used for teleconferencing or track a user's face.
Depth sensor	PMDTec CamBoard	A USB based TOF sensor. Producing a depth map of 200x200 pixels. Capable of effective detection in a short range of 40cm. Used for hand gesture and multi-touch detection.



LuminAR Bulb sensors: (a) PMDTec CamBoard (b) Sony PS3 Eye Webcam (c) Microsoft Lifecam NX-6000

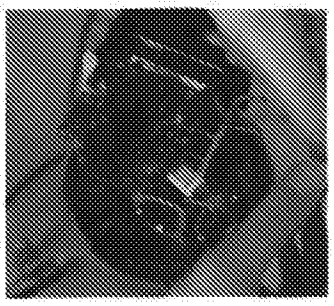


LuminAR Bulb webcams and sensors

The final design iteration of the bulb was specifically developed to match the LuminAR Blackjack and LuminAR Retail Arms (we describe these systems later in this chapter). While dealing with demo deadlines and hardware integration pains, our efforts to fully integrate the PMDTec sensor with the bulb failed. The cause is most likely due to electrical ground noise in our design that damaged the PMDTec sensors. To work around this issue and meet our demo deadlines we

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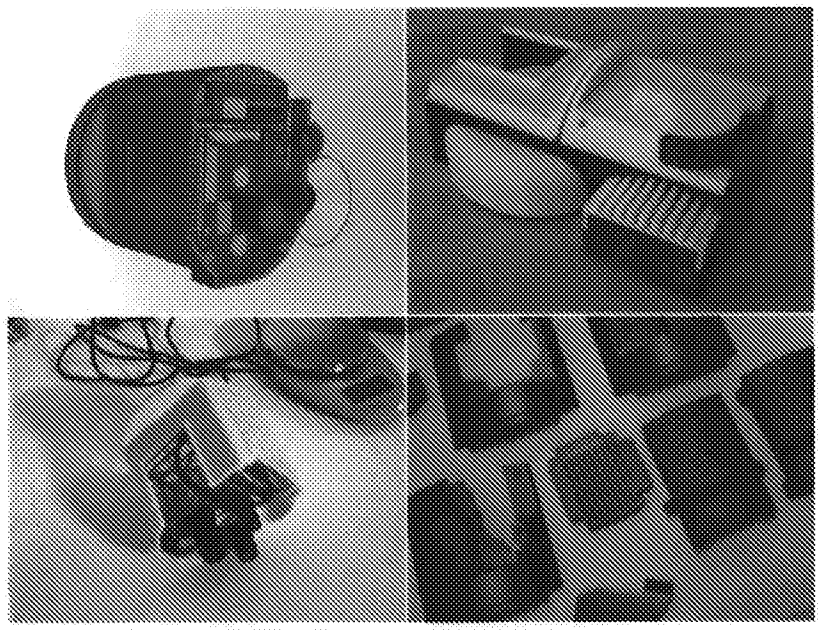
created another version of the bulb using an additional Sony PS3 webcam instead of the CamBoard.



Mounting two Sony PS3 webcams, on the bulb

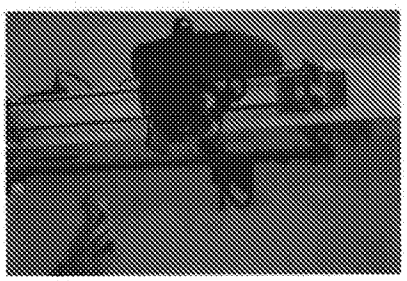
Designing the shells

Finally, the bulb is enclosed in four shells: one fixed, attached to the main shaft flange, and the rest connected to the aluminum frame. The pico-projector and the onboard computer both have custom heat sinks used as part of the bulb shell. The shells were designed in two iterations, we 3D printed the initial design and preformed basic fit testing to the frame. Later on, the design was refined and was fabricated from ABS plastic.



Steps in the design of the bulb covers included iterations of rapid prototyping using 3D printed covers. Final covers were fabricated from ABS plastic.

Conclusion

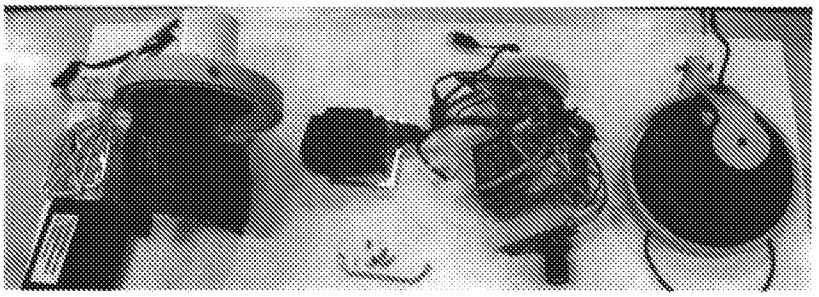


Testing the LuminAR Bulb in a standard light fixture

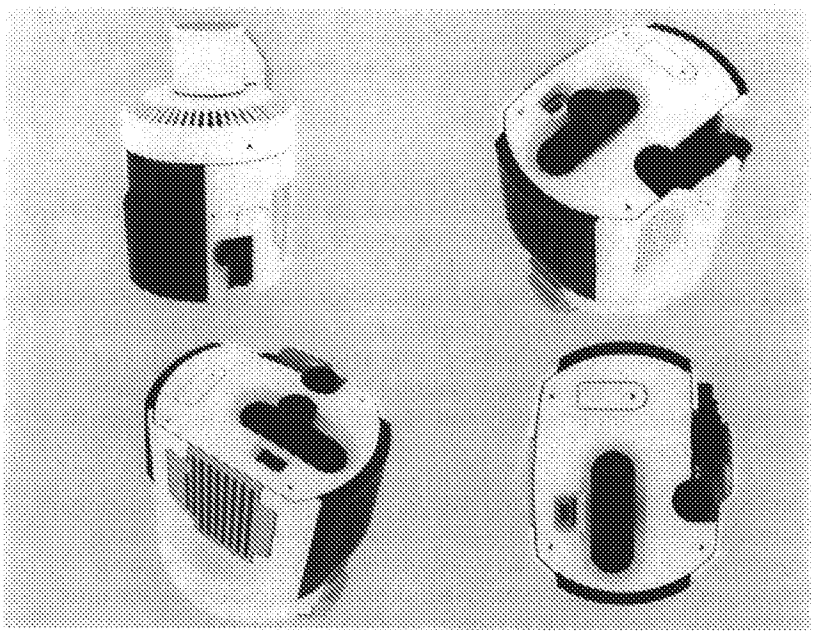
The bulbs we fabricated during the integration iterations met an important functionality goal. We developed a functional bulb prototype and were able to test it both on LuminAR Arms and as standalone installations in standard sockets. The final design of the LuminAR bulb completed a series of explorations that pushes forward the design and engineering of compact projector-camera systems. It is also to the best knowledge of the author, the first example of a kinetic and computer embedded

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system. Naturally the LuminAR bulb is still a preliminary prototype and has to go through several improvements (e.g. integrating ambient sensors, better depth sensing, improved cable management etc.), but those are at this point, beyond the scope of this thesis work.

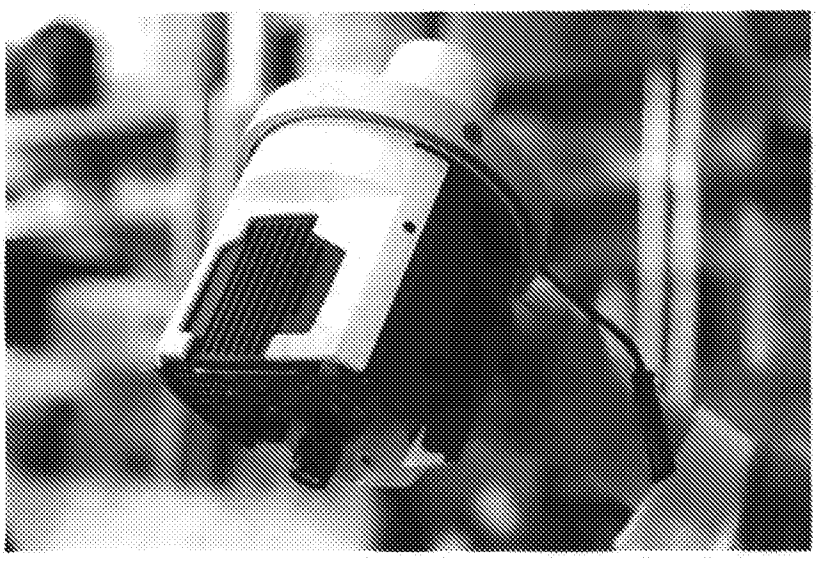


Steps in constructing the final prototype of the LuminAR Bulb



Renders of the final design for the LuminAR Bulb (rendering: Jason Robinson)

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The final LuminAR Bulb

LuminAR Lamp

For the sake of formal definition, the LuminAR Lamp is comprised of custom robotic arm (i.e. LuminAR Arm), which is designed to interface with the LuminAR Bulb. The two together, are combined to create an articulated version of the classic Anglepoise task light.

Design goals and process

In chapter 2, we describe the product design space for LuminAR. Specifically, The design of the LuminAR Lamp is an attempt to embed computation and interfaces in everyday objects.

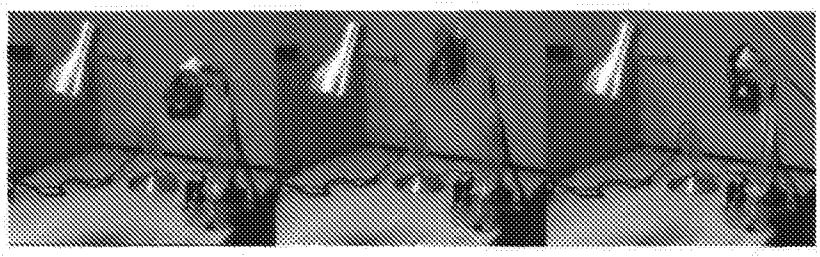
The challenge was in hiding the technology, making it invisible to the user. To do so we had to reinterpret the classic Anglepoise design, evolving it into a new yet familiar interactive object. In fact, we can think of the lamp as new form factor for a computer which uses projected augmented reality and natural interaction techniques as its main UI modality.

Much like the LuminAR Bulb design, the LuminAR arm development process was iterative. In the early stages of the project we have employed an agile approach, pushing for very short prototyping iterations. The lessons from one prototype generation fed the next. Overall we developed and tested six different arm prototypes.

The Anglepoise Type 75 Reference

In chapter 2 we provided a brief review of inspirational task lights that served as inputs for our design process. However to translate our design into actual mechanically operational system we decided to use the Anglepoise Type 75 as our main study model. Early on the LuminAR arms follow the proportions and to some extent some of its aesthetics.

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Testing of the first LuminAR arm proportions compared to an Anglepoise Type 75 Lamp

Mechanical System

Before we dive into the description of the various LuminAR Lamp prototypes, it is important to review the basic mechanical operation principles they all share.

As we described in chapter 2, LuminAR follows the classic Anglepoise counter balanced arm design, where the force of gravity of the bulb and lampshade is counteracted by extension springs. This allows static positioning of the arm within its affective reach envelope.

The arm uses a four-bar linkage system, more specifically a parallelogram, to translate the movement of the upper arm of the system to a small linkage closer to the base. This enables the counterbalancing spring and any actuator for the upper arm to apply actuation on the small bar and, as a result, be positioned lower, closer to the base.

For a complete review of the physical, mathematical model and mechanical working principle that govern counterbalance systems we refer the reader to the excellent review by French et al. [19].

Topology

The arm itself has four rotational degrees-of-freedom (DOFs). The first DOF is located in the base of the lamp, allowing the Base-DOF to rotate in the horizontal plane, in a range slightly less than a full 360 degrees.

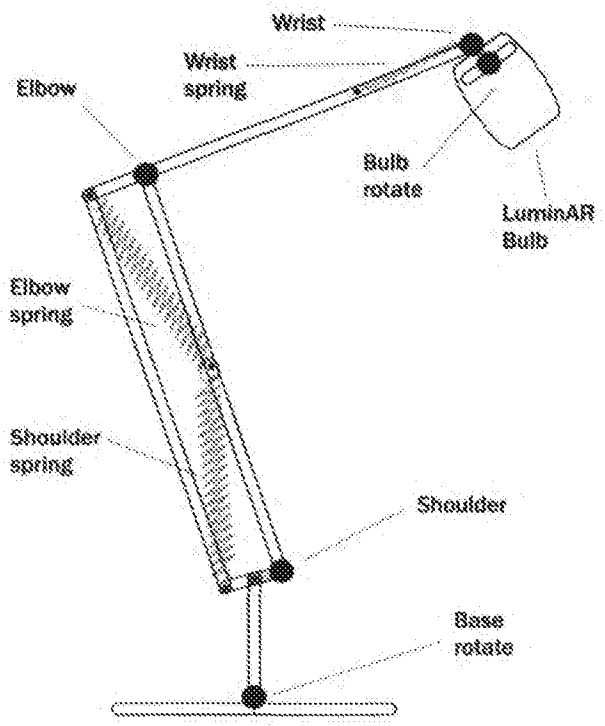
Next, The DOFs are named accordingly with respect to human arm metaphor: the Shoulder-DOF, Elbow-DOF, and the Wrist-DOF are located on a single plane, orthogonal to the Base-DOF. The Shoulder-DOF and the Elbow-DOF are positioned directly above the base on a mechanical fork structure.

The fork is a support structure for the servomotors and shafts that actuate the elbow and shoulder links of the arm. Finally, the Wrist-DOF is located at the end of the Elbow-link, though the actuator can be mounted elsewhere in the structure of the lamp.

The Shoulder, Elbow and Wrist DOFs are spring loaded, each with it's own separate extension coil spring. The springs counter the mass of the links and the arm's payload, and the LuminAR bulb. Actuating the balanced arm required to output enough torque to overcome the friction load. The Wrist-link has an interface for the Edison 27mm

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female bulb socket. Overall, the lamp has 5 rotational DOFs, including the additional rotation inside the Bulb.



LuminAR Lamp mechanical system topology, the diagram shows the lamp's DOFs and extension springs.

In the sections that follow we describe the different LuminAR lamps we have developed over the course of this thesis work.

Prototypes

LuminAR Optimus

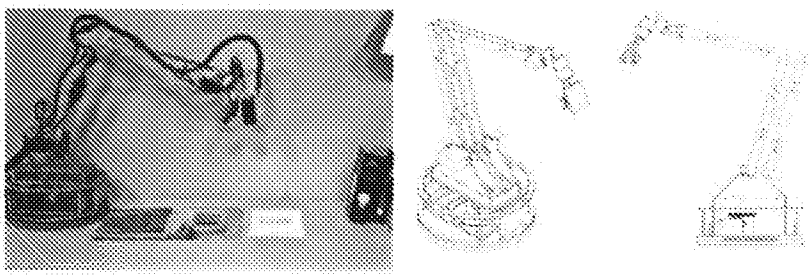
Optimus was our first fully functional prototype. Its main purpose was to serve as a learning platform for the mechanical subsystems and begin exploring concepts of kinetic user interfaces.

Optimus had a heavy round base that was constructed from a heavy 0.5" MDO board, fitted with an aluminum construction (0.25" Aluminum sheets). The base rotation mechanism used a central stationary shaft fitted with a gear. A servomotor with a 1:2 gear ratio was engaged to central shaft gear giving it 180 degrees of rotation.

On top of base structure we designed an acrylic structure that supported the elbow and shoulder servomotors. The elbow and shoulder springs extended from the four-bar arm linkage to a screw-bolt

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holder in the bottom of the base. The arm was also constructed from acrylic laser cut parts that were press-fitted and glued.



LuminAR Optimus

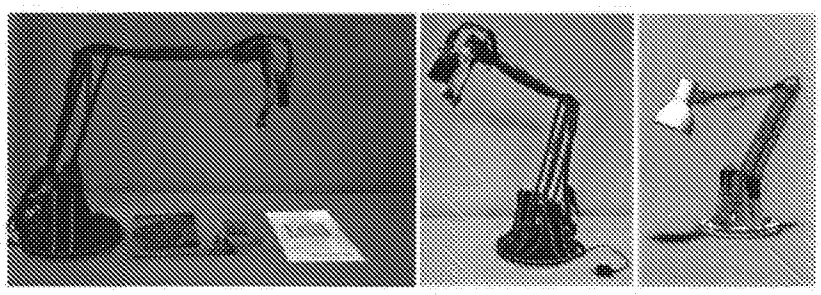
Optimus had a bulb socket construction, but it did not provide power. One of the early LuminAR Bulb rough prototypes was installed on Optimus. Wiring was done through the gap between the arm bars, making sure the cable has enough bend profile. This problem persisted and always required attention in all of the prototypes we created.

Optimus was used extensively in our concept mock-up scenarios, and some of the demos we created are available on the MIT Media Lab – LabCast website [91].

LuminAR Aluminum

Our second prototype was named Aluminum, as it was the main material used for this prototype. The transition to metal was trivial, as wood and acrylic did not provide the robustness and accuracy desired for the kinetic interaction we envisioned.

Aluminum also had a refined low profile base. The base was implemented using a simple turntable and a central gear. The servomotors mounting structure and the actual arms were also streamlined, pushing towards a design that resembles a real Anglepoise task light.



LuminAR Aluminum

Actuation

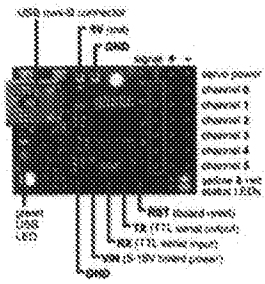
Both Aluminum and Optimus were actuated using simple R/C servomotors. To control them we used the commercially available servo control board Maestro Micro from Pololu. The Maestro Micro major

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advantages are its tiny size, and the simple USB-based programming interface.

Control

Optimus and Aluminum were both connected to a netbook running Linux (Ubuntu 10.4). Control was done using RS-232 over USB. Projection was supported directly using the netbook's VGA port.



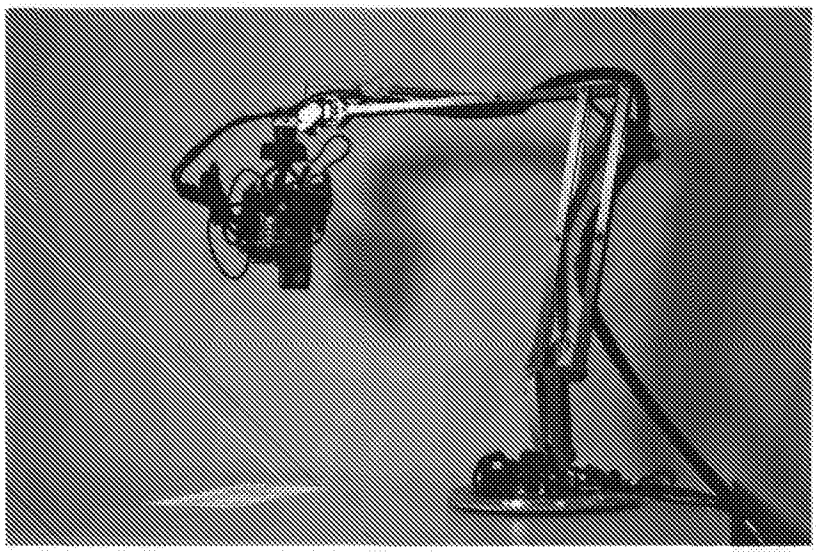
Pololu Maestro Micro servomotors control board (source: Pololu)

Early software versions

To begin the LuminAR software stack design, we started with quick prototypes using a Python based control server, while our front end UI was based on the QT4 GUI toolkit.

LuminAR Tipsy

Tipsy represents a major revision in many aspects of the LuminAR Lamp evolution. Anecdotally, Tipsy got its name due to a miscalculation of lamp's base weight, which caused it to tip and lose balance. Even though far from perfect, Tipsy represents our attempt to reach the proportions of a real task light. It also represents a system integration milestone, as it was tested with an almost fully functional LuminAR bulb.

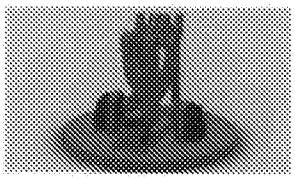


LuminAR Tipsy

Based on our experience with LuminAR Aluminum, we were able to introduce important improvements to the mechanical and product design.

First, we improved on the base rotation mechanism. Stirring away from the use of turntables, we designed our own ball-bearing system. Doing so allowed us to reduce the base diameter further.

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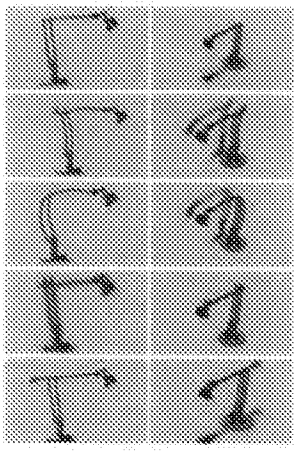


LuminAR Tipsy has a new central for element, which enabled us to position the motors on the base plate

Next, we designed a new central shaft and a new fork element. The fork allowed us to align and mount the elbow and shoulder servomotors directly on the top of the base plate. This approach saved redundant use of aluminum wings above the servos. To implement this, we added custom servo horns and linkages that provided the actual hinge to the elbow and the shoulder DOFs respectively. It also allowed using a single central shaft in the fork structure.

Finally, we were able to fit the springs for the elbow and shoulder DOFs elegantly in the gap between the lower arm linkages. Mounting the springs there contributed to the overall range of motion as well as to the overall form of the lamp. As the design of Tipsy was clean and simple we could easily explore different configuration using the same basic platform.

Actuation, Electronics and Control



Configurations we created based on Tipsy's design

Tipsy was our first model to incorporate a power supply. 110VAC was supplied to the bulb socket attached to the Wrist, while 15VDC was supplied from a PSU mounted on the base. It was used to feed the arms' servomotors. A small USB-Dynamixel board mounted on the power supply supported the communication to the bulb encoder. In our original design we also included external position sensing for each DOFs. This was to be accomplished using POTs that were mounted on the DOFs shaft. All encoders were then connected to a small microcontroller at the base of the lamp.

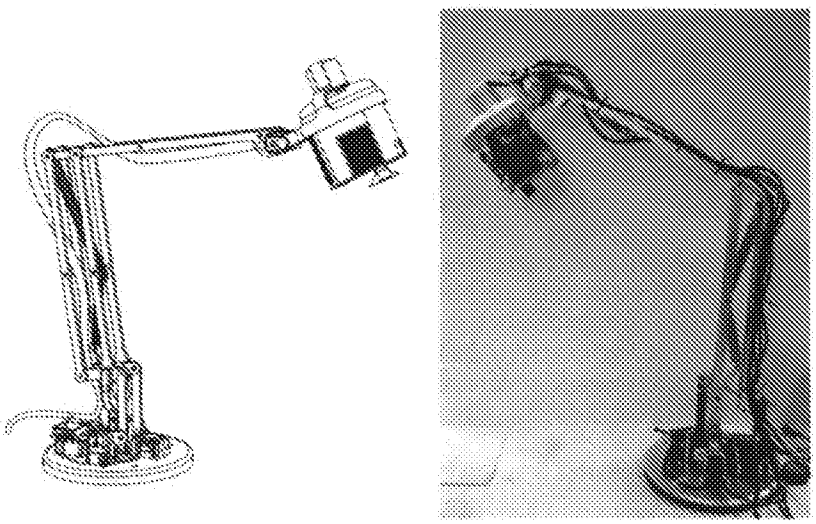
Tipsy was actuated by four Robotis Dynamixel servos (DX-117). We decided to upgrade the arm's actuators after we damaged or broke several giant scale R/C servos (e.g. Hobbico CS-80). Although clearly more expensive, the Dynamixel servo system [92] has clear advantages in sensing, networking and torques compared to standard R/C servos.

Tipsy was the first arm to be fully controlled by our very own integrated LuminAR bulb version. It was also the first platform on which we developed and tested the LuXor software stack that we describe later in this chapter.

LuminAR Silverjack and Blackjack

One of the main goals of this thesis work was to embed computation in everyday objects, and the main innovation the Silverjack and Blackjack revision represents together with the new LuminAR bulb is the creation of a new actuated interactive robotic task light. In this iteration we focused on the industrial and product design details that pushed our prototype further, so it is a 'designed object' and one that could be perceived as such by users.

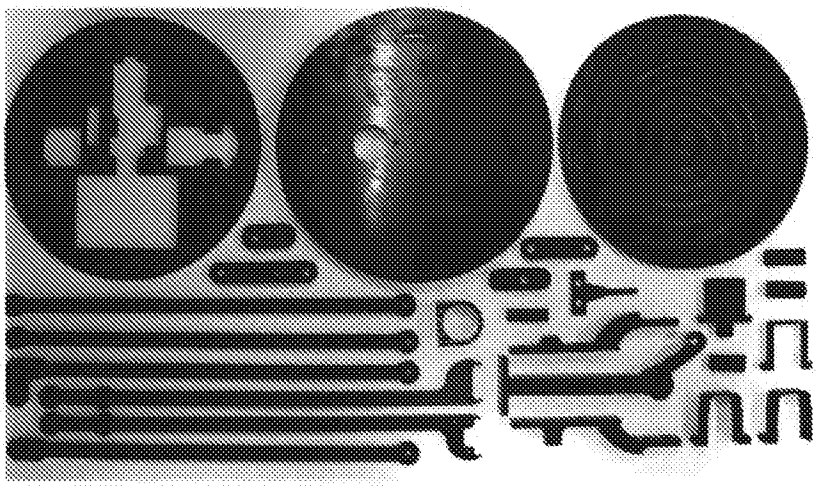
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LuminAR SilverJack and Blackjack. (photo credit: Doron Gild)

Silverjack and Blackjack were heavily based on the Tipsy design. They were designed for a short run professional manufacturing. The use of professional manufacturing techniques clearly upgrades the final result in terms of product design but also contributes to accuracies and tolerances, which has a direct effect on the overall mechanical performance of the system.

The SilverJack and Blackjack revisions also included mechanical improvements. The main fork was revised to provide better reinforcement for the servomotors. The base rotation mechanism was also improved to use anti-backlash gears and a central shoulder screw.



LuminAR Blackjack fabricated parts before assembly

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LuminAR Blackjack. (photo credit: Doron Gild)

LuminAR Retail

The LuminAR Retail arm design was specifically developed to integrate into the Augmented Product Counter (APC – see: Chapter 5 - Applications). This revision explored how our design can be manifested in a future retail environment.

Conceptually, LuminAR Retail is an adaptation of the LuminAR Blackjack tabletop arm design to a counter-top lamp for use in public spaces. In addition, the arm's design had to take into account the physical dimensions of the installation space, and to account for the APC projection real-estate requirements.

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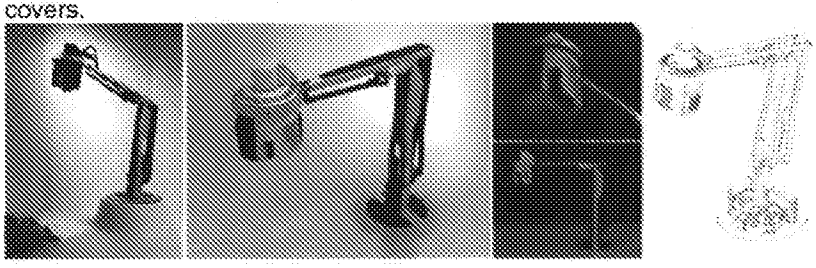


LuminAR Retail design process used existing lamps as platform for physical modeling and form exploration.

To accomplish that, our design process used the existing Silverjack model as a physical prototyping platform. Using this approach, we were able to reuse most of the base components, while developing the new proportions and working envelopes that were extended to cover larger workspace.

In order to streamline the final form of the retail arm we repositioned the wrist servo, locating it in the back section of the upper arm linkage. The result was a clean and simplified connection point between the bulb interface and the upper arm wrist joint. The motion was transmitted to the wrist DOF using a custom made horn and linkage that was mounted under the upper arm.

In addition, the retail arm makes extensive use of casing and covers. We used black ABS plastic custom made covers to obfuscate technical components as much as possible. In the final version we included covers for the arm linkages (top and front), bulb interface and base covers.



LuminAR Retail (photo credit: Doron Gild, rendering: Jason Robinson)

Due to its larger size and mass, to maintain an effective work range, we had to upgrade the servomotors for the Shoulder-DOF and Elbow-DOF from Dynamixel DX-117 to Dynamixel EX-106+, which provided the required torques to handle LuminAR Retails' increased dimensions and weight.

Conclusion

In the course of this thesis work we have developed six robotic arm platforms that were used to evolve the LuminAR Lamp concept. We were able to quickly use our insights across multiple iterations. However, our real goal in the design of these objects was actually to make the technology, specifically the robotics, disappear altogether.

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We believe we provided a valid first step for the design and implementation of such future actuated task lights. But, we are also aware that our hardware is limited, many improvements can and should be applied mainly to the actuation and sensing subsystems, and to the overall cost reduction of the arm, so it becomes commercially viable.



LuminAR Retail projecting a keypad (photo credit: Doron Gild)

LuminAR Spotlight

LuminAR Spotlight is a ceiling or wall mounted, actuated carrier fixture for the LuminAR Bulb. It was designed to add articulation capabilities to static track lights and light fixtures. Combined with the projected augmented reality interface the LuminAR bulb provides, it creates dynamic interactive physical spaces.

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Our goal in designing LuminAR Spotlight was to develop additional kinetic form factors, which can be embedded seamlessly in a physical space and explore the interaction techniques it affords. In this section we describe the Spotlight prototypes and discuss two variations of the Spotlight concept. The first uses an articulated linear track. The second variation uses a pan/tilt mechanism.

Design goals

To complement the general design concept of spotlight, we defined the following design goals for the system we created:

- Spotlight can be mounted on a ceiling or wall, taking advantage of the additional height and projection angles above and around a workspace.
- Spotlight devices should be designed to completely blend into the physical environment.
- Spotlight should support natural interaction modalities
- Spotlight should be able to communicate with other LuminAR devices, complementing the use case (this was actually achieved in the APC project – see Chapter 5 – Applications)

Prototypes

LuminAR Spotlight LS

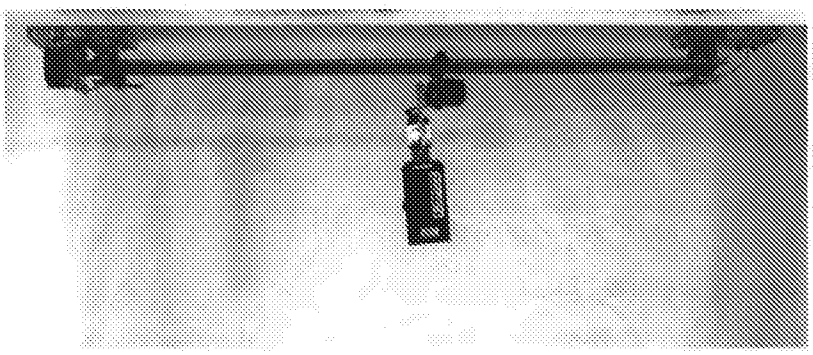
Our first approach explored the concept of actuated track lights. We focused on building a quick prototype to be able to tackle challenges like actuation and retractable cable management.

The Spotlight LS system consists of a linear shaft based track and a carriage with an R/C servomotor tilting head, giving LuminAR Spotlight two degrees of freedom. The carriage head interconnects with the LuminAR bulb through a standard Edison bulb screw socket.

In this version, motion was transmitted from a stepper motor through a fast lead screw that carried the bulb carriage. It had no position sensing except a far and near switches at the end of shaft tracks. We used a small microcontroller and motor driver board to open-loop control the position of the carriage. The micro-controller was then hooked to the LuminAR Bulb netbook computer, giving the bulb control of its location along the track.

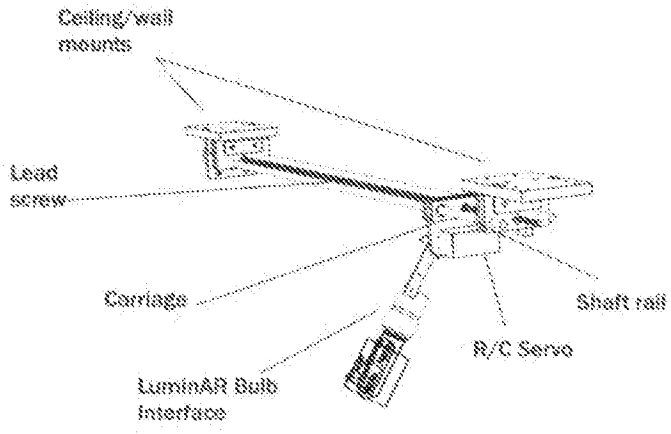
The carriage position could be estimated using a time-based calculation. The actual location of the carriage was calculated using rotation revolution count. Integrating the lead screw pitch with the number of steps the stepper motor performed in a given time slot, provided the estimated distance the carriage travelled.

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LuminAR Spotlight LS

However, this approach gave average results and was one of the reasons the use of lead screw was abandoned in the next version – Spotlight BD (belt drive). The other reason we opted to replace the lead screw actuation method were the slow speeds it provided and the high noise levels.



LuminAR Spotlight LS – mechanical design

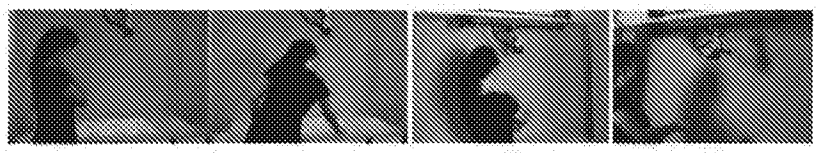
Interaction with Spotlight

Spotlight LS also served as a platform to explore different interaction techniques that we already developed for the LuminAR Bulb, and specifically new methods that are unique to Spotlight.

First, we were able to dynamically control the location and orientation of a touch enabled projected interface. This concept could be used to dynamically choose the projection location. For example, we could decide on a horizontal surface (e.g. a tabletop), and then using a gesture, direct the Spotlight to project on a vertical surface (e.g. a wall).

Next, we could have the Spotlight track a fiducial marker. This is be used to track and object under the spotlight. We were also able to used similar techniques to track a users hand.

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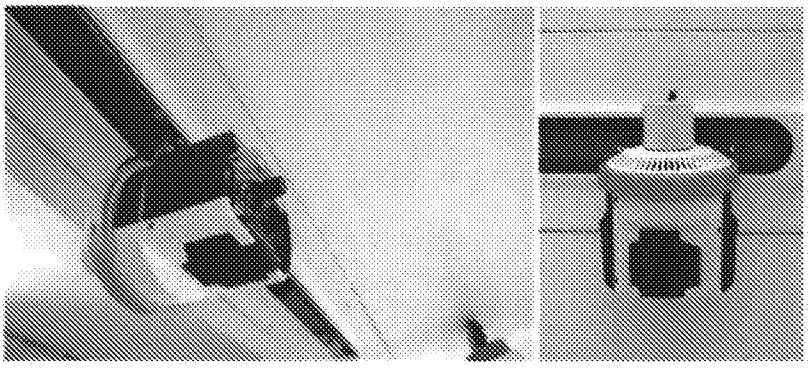


(a) (b) (c)

LuminAR Spotlight interaction techniques include: (a) projected mutlitouch, (b) hand tracking and, (c) tracking fiducial markers

LuminAR Spotlight BD

Following our early general explorations with Spotlight, we started working on a specific version of the Spotlight for the Augmented Product Counter project. From an interaction point of view, this version was designed to provide an 'Expert Wall' feature; we describe this scenario in Chapter 5 – Applications.



LuminAR Spotlight BD

The Spotlight BD prototype represents a major upgrade of the mechanical and electrical systems. But not less important, we were able to meet one of our design goals and develop a solution that integrates into a ceiling cavity, hiding all the technology under the hood.

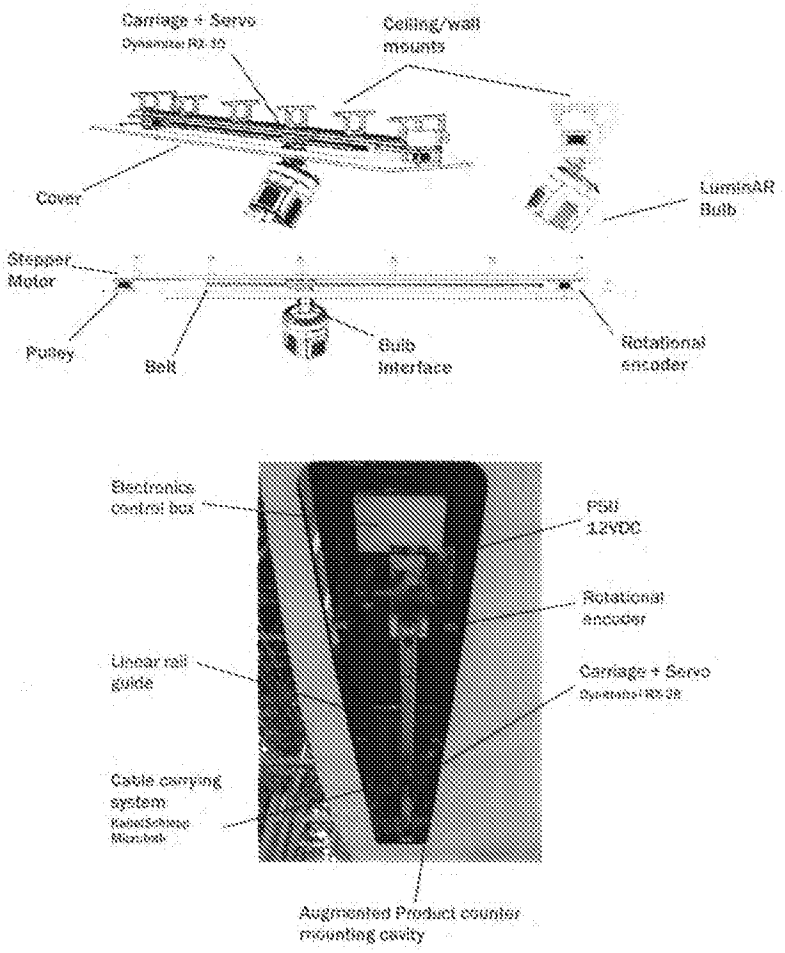
Mechanical engineering

Similar to the Spotlight LS, the system consists of a linear track and a carriage with a tilting head, giving LuminAR Spotlight BD the same two degrees of freedom.

The linear motion is generated by a stepper motor, positioned on one end of the rail and transmitted through a belt and pulley drive mechanism. The idler pulley shaft is equipped with a rotational encoder to track the carriage position. The belt and pulley proved a better solution, in terms of ambient noise, and position sensing control accuracy.

The carriage head tilt is accomplished by a servo mounted on the carriage. The servomotor was upgraded to use a stronger Robotis Dynamixel AX-10 servomotor. The servomotor was fitted with a standard bulb interface.

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LuminAR Spotlight BD – mechanical design

In this version, we had to provide a better solution for continuous retractable cable motion. We integrated a KabelSchlepp Microtrak cable carrying system. The Microtrak was an ideal choice as it is lightweight non-conductive yet very durable and easy to integrate.

Electrical engineering

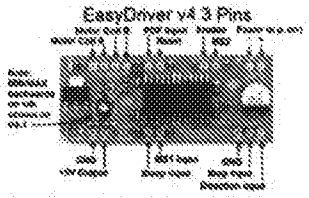
We created a custom control electronic board for the Spotlight BD. It was important to create the board so the entire system could be used stand alone, requiring only power connection and the LuminAR bulb to operate.

The entire system was fed by a power supply that provided motors with 12VDC line, and a 5VDC line for the control electronics.

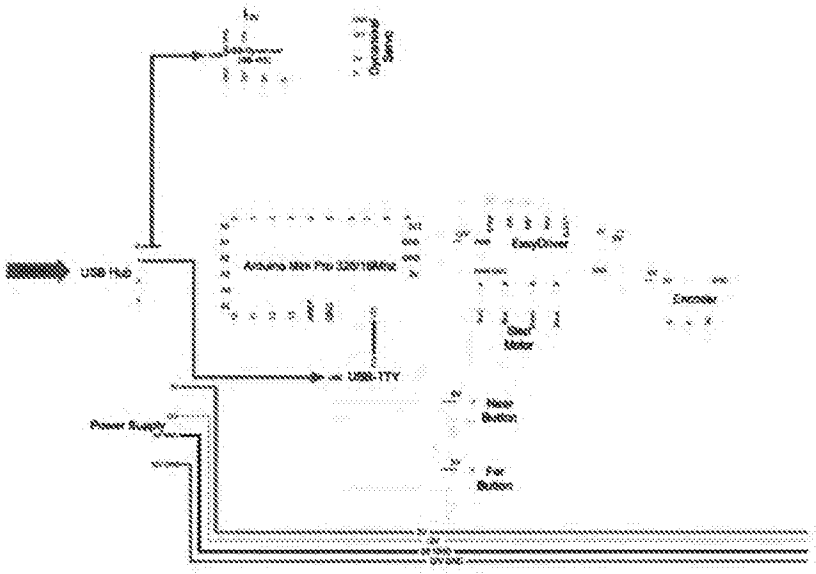
The board controlled the stepper motor using a small microcontroller (Arduino Mini Pro 238/16Mhz), connected to a commercially available stepper motor control board form Sparkfun called EasyDriver. The

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EasyDriver board provided a simple control interface to the motor's step and direction. The near and far switch sensors were connected directly to the microcontroller, providing stop-switch mechanism when the carriage reaches the end of the linear track. The rotational encoder is also connected directly to the microcontroller, providing a closed-loop control.



EasyDriver stepper motor control board
(source: Sparkfun)



LuminAR Spotlight 8D control electronics board schematics

The board included a USB hub that provided interfaces for the FTDI RS-232 / USB interface boards, used by the microcontroller and the Dynamixel servo communication interface.

The board was placed in a plastic box, mounted on the linear track rig, and fitted with ON/OFF LEDs for indication purposes. The microcontroller on the board firmware provided simple interfaces to initialize the system control and query the location of the carriage on the track.

LuminAR Spotlight360

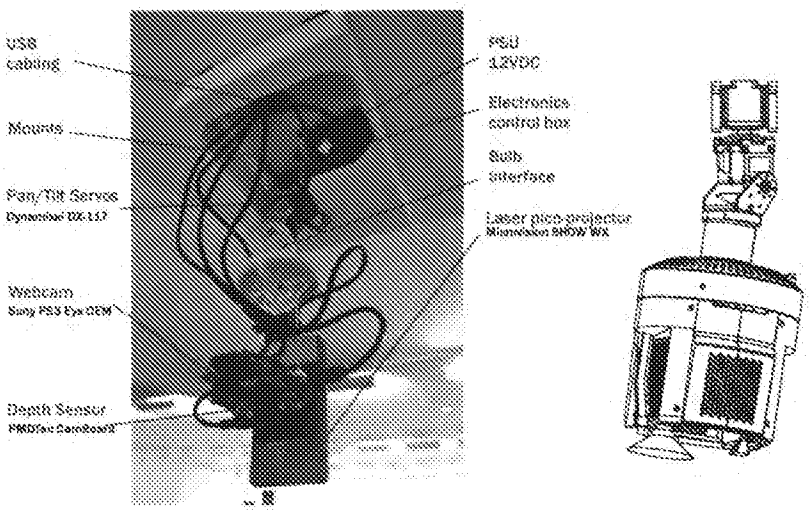
The final Spotlight exploration we created is called Spotlight360. It is a simple fixture, built from two Dynamixel DX-117 servos, the first serves as a rotation axis (pan) and the second serves as a tilt servo. The second servo interconnects with the LuminAR bulb through a standard Edison bulb screw socket.

The goal of this version was to provide a simple form factor capable of revolving the LuminAR bulb 360 degrees with respect to its mounting point.

In this specific iteration, we used a stripped version of the LuminAR bulb that used a depth sensor. This enabled us to use free hand

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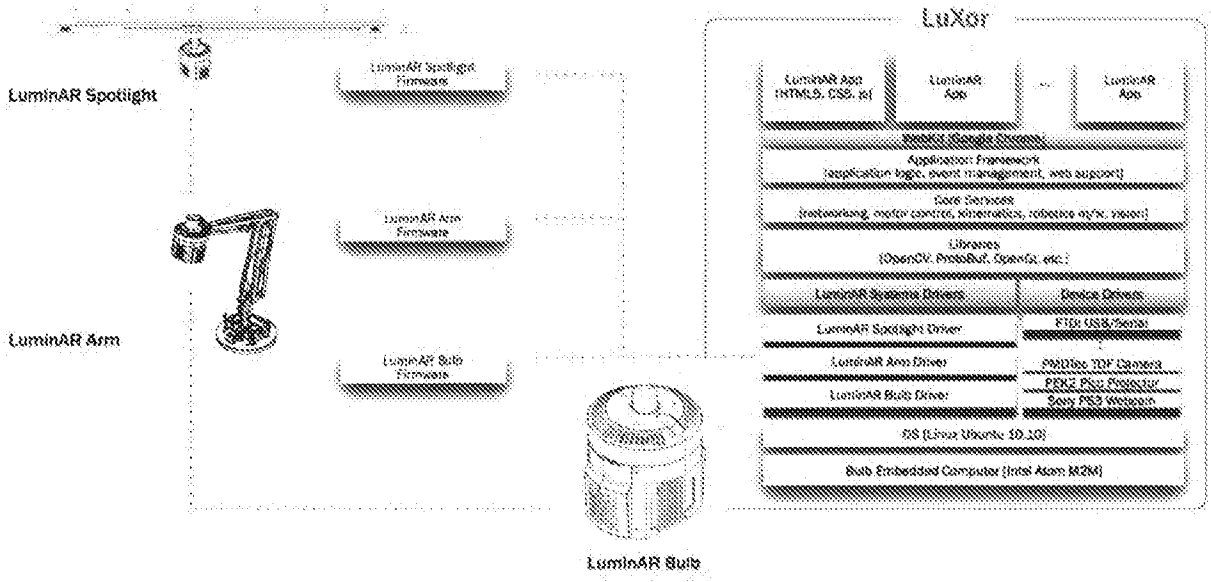
gestures (e.g. open hand, fist, pointing-finger) to control the bulb projection location and orientation.



LuminAR Spotlight360 - mechanical design

LuXoR

LuXor is the software framework and execution environment we designed and developed to run LuminAR devices. It is designed to run in the context of the LuminAR Bulb, the central computation and I/O hub for the system.



The LuXor software stack is designed to run on the embedded computer of the LuminAR Bulb. LuXor has specific LuminAR systems drivers that communicate with the firmware of the LuminAR Arm and LuminAR Spotlight

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It also provides the interfaces for the bulb to communicate with other LuminAR hardware devices. It was developed for the later iterations of the LuminAR Bulb, and specifically tested with the LuminAR BlackJack, SilverJack, and Retail arms as well as with the LuminAR Spotlight.

LuXor combines different software disciplines; to enable LuminAR devices to become interactive, kinetic and connected projected augmented reality interfaces. In broad strokes, LuXor comprises of a web based application framework and a set of core services that provide it with a hardware drivers, robotic middleware, application runtime logic, event management, computer vision services, and projected GUI utilities.

In this section we provide a high-level review of the software requirements and design considerations that motivated LuXor. We begin with software architecture overview, and continue to describe the core services and the application framework that enables developers to create LuminAR applications.

High Level Software Requirements

The software requirements for LuXor are also informed from the design principles we presented in the beginning of this chapter. We can extend some of the principles to the software domain, supporting our goal to create an interactive, kinetic projected augmented reality user experience. Finally, to complement the discussion of the high level requirements we present in this section, the reader should also refer to the Interaction Design Principles we present in Chapter 4 – Interaction techniques.

The table summarizes a set of high-level software requirements that guided LuXor's software architecture design:

Embedded	• The entire software stack should be able to run on embedded boards that have a single processor (e.g. Intel Atom MTM or ARM based systems) • The entire code base should have a small footprint so it fits in embedded storage devices • Support close to real-time constraints for computer vision, motor control and graphics • Low runtime memory requirements
Layered and Modular	• LuXor should provide good abstractions and relevant layers to separate low level drivers, system core services and application interfaces • System should be developed in a modular fashion, allowing (1) different configuration options and (2) distributing computation to

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	either additional module instances or remote modules
Extensible / Portable	• Provide interfaces to extend the system in its respective layers • Support portability of the codebase across different LuminAR devices, abstracting hardware dependent code
Connected	• LuXor should enable LuminAR devices to work in a network • Support device addressing and data exchange protocols
Application Model	• Provide a standard web based application development framework
Standard / Open	• Use open standards, allowing for easy 3rd software integration
Natural Interaction / AR Interfaces	• Provide UI modality fusion. Support standard GUI approaches (e.g. mutlitouch) with gesture detection and AR interaction techniques
Limited Installation & Calibration	• The system should require minimal configuration and/or hardware-software calibration to run
Interactive Kinetics Control	• Abstract robotics control aspects, providing mechanisms to use kinetics for application, interactive purposes

Software Architecture

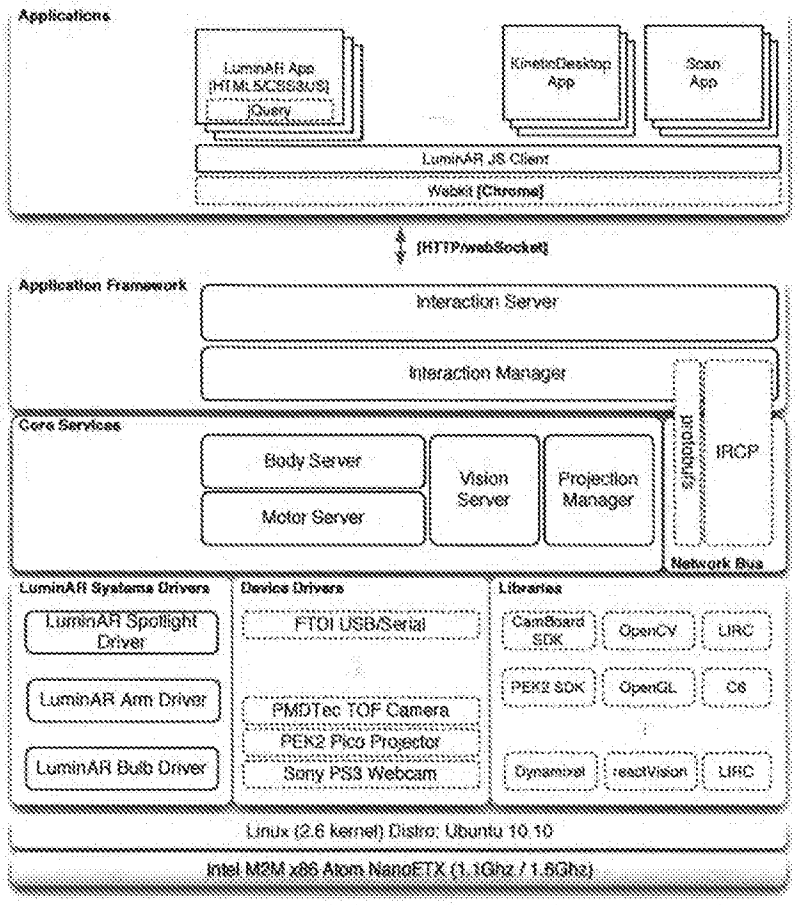
Two main areas of software design inspired the LuXor software architecture design: mobile platform architectures (e.g. Google Android or Apple iOS [93], [94]), and robotic middleware solutions (e.g. ROS from Willow Garage [95]). The LuXor architecture is a minimalistic hybrid between these two very different paradigms.

The diagram below provides an elaborated view of the LuXor software stack. In the following sections we briefly discuss LuXor's major components.

Hardware and Operating System

LuXor is designed to run on Intel's M2M Atom hardware. The M2M is an x86 platform and can easily boot Linux. LuXor relies on the Linux kernel for core OS functions and basic services such as network connectivity and windows management. We also rely on Linux driver model to support all the peripherals attached directly to the bulb's computer.

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LuXor software architecture

Components Overview

The LuXor infrastructure is designed as a layered architecture, defining the following layers and components:

- **Applications** - front-end, web-based LuminAR applications
- **Application Framework** - runtime execution, interaction and event management
- **Core Services** - a set of infrastructure components, interfacing with low level hardware (motors, sensors), exposing high level interface for the application framework
- **Network Bus** - IPC communication pipeline and data bus
- **Libraries** - includes all 3rd party dependencies
- **LuminAR Systems Drivers** - drivers to LuminAR systems
- **Device Drivers** - drivers to peripheral components of the LuminAR Bulb

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In the following sections we provide more details on the specific functionality of the various LuXor components.

Core Services

LuXor's core services layer includes a set of independent servers, each dedicated to specific services required by the Interaction Manager. The services interface with low-level hardware drivers and expose simple interfaces to the application framework.

Networking

LuXor services and application framework use a shared network bus to communicate. Inter-application communication is critical when implementing a modular, distributed system. The network bus is used to integrate independent software modules, providing simple means to send messages and data. This enables LuXor to become an event driven system throughout its different layers.

Our message description implementation was based on Google's Protobufs open source project [96]. Protobufs stands for Protocol Buffers. It compiles human readable structured message descriptors to binary protocol buffers. Protobuf also provide interfaces in various platforms, which was important when integrating a low level C++ server with a high level Python interface.

LuXor uses the Intra-Robot-Communication-Protocol (IRCP) as the transport layer for the network bus. IRCP is a thin layer of networking logic, implemented on top of UDP transport protocol. It provides Python, C++ and Java interfaces. IRCP handles the basic network creation, address resolution and basic error checking. It provides simple interface to send typed data packets or send streams of data. IRCP was developed at the MIT Media Lab Personal Robots Group [97].

Vision Server

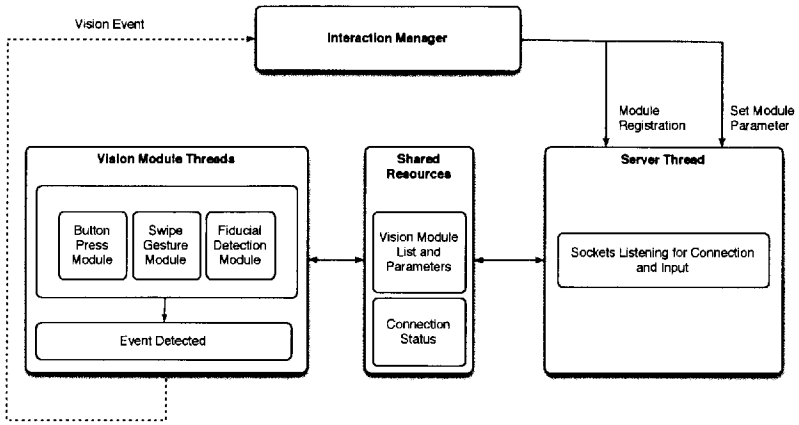
The vision server's role in the LuXor system is to manage input from the various cameras in the LuminAR bulb and produce interaction events such as the pressing of a button, detecting a hand gesture or the presence of an object. Events are propagated to the Interaction Manager where they can trigger application level state changes.

The server was developed in C++ using OpenCV [98] and reactiVision [99], and was optimized for embedded performance. It also manages the access to shared camera resources, providing thread safety. The server modules could also be deployed on multiple machines thanks to LuXor's network bus. This was useful when the vision tasks were pushing the limits of the Atom based platforms we were using.

The server generalizes and abstracts the interface to cameras and sensors, exposing multiple a functional interface using vision modules. The vision server owns a dynamic array of vision modules, each of which represents an independent thread processing video and

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producing events, which can be sent asynchronously to the interaction manager.



LuXor's Vision Server vision events flow

Vision modules need not only the ability to send events but also the ability to receive information from the Interaction Manager about the application state, such as the location of buttons on a page. We implemented modules to detect button press, hand swipe gestures and a fiducial marker tracker module. We also experimented with depth based touch detection module using PMDTec CamBoard USB Time-of-Flight(TOF) sensor [100].

The Vision Server modules assume homography between the projected display and the camera viewpoint. The homography is accomplished using a one-time simple calibration process in which camera pixels are correlated to projector pixels. The calibration data is then saved to a configuration file.

Button Press Module

To allow LuminAR to determine when a button in the projected user interface has been pressed, we initially turned to using a time-of-flight depth-sensing camera from PMDTec. The sensor measures the distance of objects by sending out pulses of light and then measuring the amount of time it takes for the light to return to the camera, with a resolution of 200x200 pixels and measurements in meters. After calibrating the sensor, we found the depth value at each button by sampling the depth image and then forming a virtual hemisphere a small number of that point. This technique was also used recently by Wilson using a Kinect sensor [68]. Then, by the number of depth pixels in that 3D volume we determined whether or not a finger was present on the button. We found, however, that the thickness of the average finger was not significantly larger than the noise level in the depth frames, and so we had a large number of false positives with low values of the threshold and a large number of false negatives for high values of the threshold. That, combined with technical issues regarding the depth sensing hardware, forced us to use simple webcams as an alternative.

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As a replacement, we decided to use a webcam (Sony PS3 Eye OEM) with a far simpler scheme. We found that the saturation values for both the white table and the projection on it were very low, while the saturation values for hands over the table and the projection was quite high, so thresholding the values of saturation within the region where the button was located allowed us to reliably determine when a button was present in that area, signifying a click.

Clearly, this approach was aimed at giving us minimal vision based interaction capabilities and we can use it explore many applications that require simple touch capabilities. Using the Vision Server's architecture it is easy to add additional modules that will improve the detection capabilities with finger tracking and hand gesture detections mechanisms.

Swipe Gesture Module

The Swipe Module allows the user to perform a swipe gesture beneath the LuminAR Bulb viewport, and determines the direction the swipe was made, either right to left, left to right, top to bottom, or bottom to top. To determine the presence of a swipe and its direction we initially attempted methods involving optical flow, but found that they were not lightweight enough for the Atom hardware considering the vast amounts of additional processing that was necessary. Instead, we chose a far simpler method that used the same hand extraction by saturation thresholding as the button press module.

Fiducial Detection Module

To detect the presence and location of objects in the LuminAR view, we used fiducial markers. reacTIVision [99] is an open source implementation of fiducial marker detection we opted to use. It sends fiducial information over a socket, so in the Vision Server we created a module that listens on the reacTIVision port and forwards fiducial events up to the Interaction Manager indicating the presence and location of objects with fiducial tags.

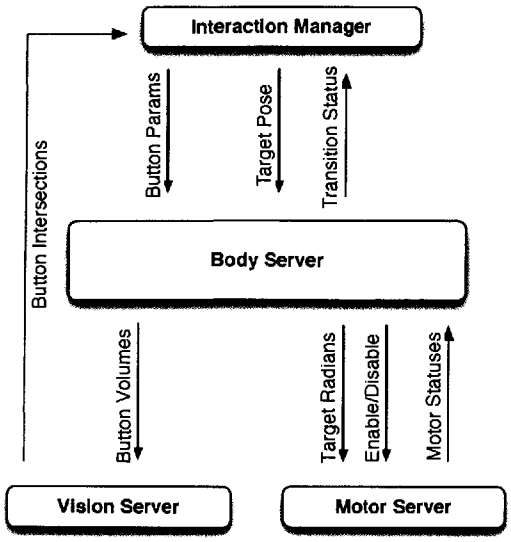
Body Server

The LuXor Body Server is a small-scale robotic middleware layer. It is in charge of controlling LuminAR devices pose. It also abstract this function from the application, providing an interface to manage poses.

The Body Server also handles the entire kinematics calculations specific to the device (i.e. The LuminAR Arms and LuminAR Spotlight have very different kinematic models). Using the kinematics model the Body Server is also responsible to load and maintain the Vision Server calibration data.

The diagram below shows the main flow of the Body Server.

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LuXor's Body Server event flow and interfaces

The Body Server continuously communicates with the Interaction Manager to monitor and control the pose of the LuminAR device. Once an application has reached a state in which the application is required to move, the Interaction server would request a logically defined 'Target Pose" from the Body server. The Body server in turn translates the logical target name to actual motor coordinates in radians and forwards them to the Motor Server. Once a motion sequence is complete the Body Serve returns the interaction control to the Interaction Manager.

Motor Server

The LuXor motor server provides an abstraction for low-level motor control required of LuminAR devices. It provides a means to configure multiple motor configurations per device. It also allows for multiple device configurations. This feature was extremely useful when defining complex devices with separate motor configurations like the LuminAR Spotlight or the LuminAR Lamp.

Projection Manager

The Projection Manager was designed to interface with the application framework to provide display manipulation routines. The PEK2 SDK provides hardware-based keystone and projection angle manipulations that could help deal with geometrically correcting a projected image. Unfortunately we did not have sufficient time to fully complete and test this manager.

Application Framework

LuXor's application framework provides runtime execution environment, state management and event distribution mechanisms. It is designed to support a simple yet powerful web-based development environment.

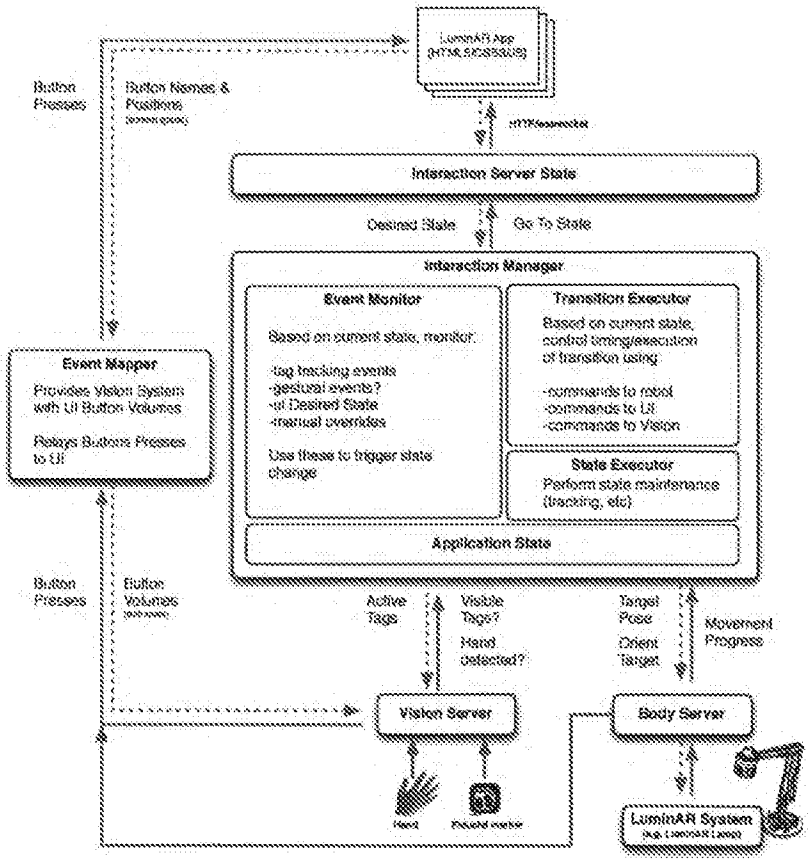
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Interaction Manager

The heart of the Application framework is the Interaction Manager. It is responsible for managing the entire application lifecycle. The manager has direct interfaces to the Body Server and the Vision Server.

Two key mechanisms govern the server main loop. First, the *Transition Executor* is responsible for maintaining the current logical state of an application. Each state is defined by a set of transitions that corresponded respectively to the logic of the application pages. We discuss the general structure of LuminAR applications in the next section of this chapter.

The second mechanism is the *Event Monitor and Mapper*; it generates triggers based on incoming events in the system. Events can be either I/O driven from the application level or internal system events. Triggers invoke the State Executor completing the event flow loop. The diagram below summarizes the interaction manager event loop.



LuXor's Interaction Manager logic diagram, event management components and interaction events flow

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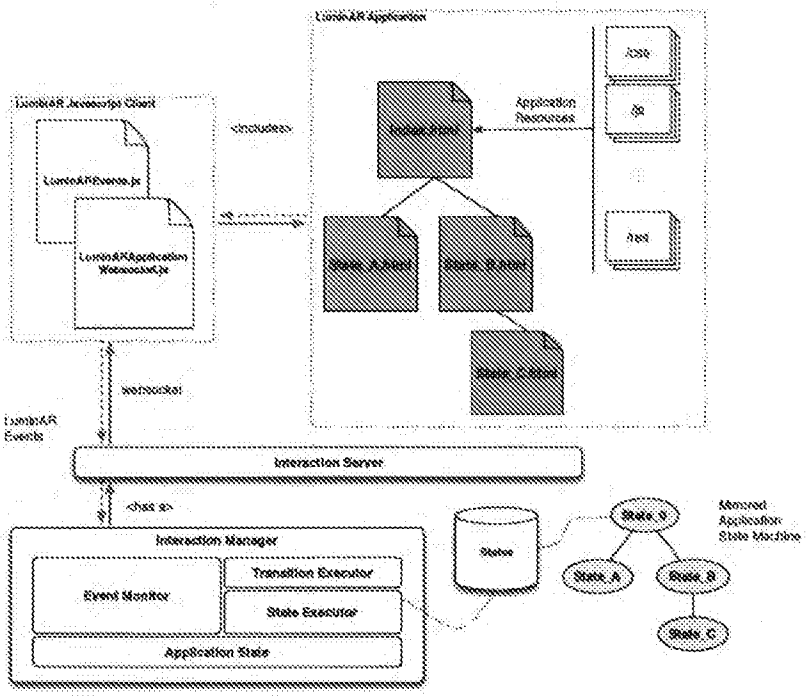
Interaction Server

The interaction server is responsible for relaying events, and state changes to and from LuminAR Applications. The server has a direct interface to the Interaction server, and a socket interface for LuminAR application to bind to. The server also has a registry for LuminAR events.

LuXor Applications

LuminAR applications are in fact web apps. Modern web browsers like Webkit, Chrome and others support the powerful new HTML5 and CSS3 specifications and Javascript provides a platform portable development environment. These new browser capabilities combined with visual java script toolkit such as jQuery provides an excellent front end GUI development platform.

Developing application code in a document driven, scripted environment has numerous advantages to the traditional programming alternative. Two advantages are important to note: (1) in a web application all the resources are packaged with the application, and the browser has a rich set of capabilities to render audio, video and various graphic formats. (2) Web based applications are easy to integrate with practically any web service or API that exists online.



The LuXor application runtime model

The challenge we had to tackle is how to robustly connect the browser front end to the LuXor backend. This was accomplished using a custom JavaScript client we developed. Once the client is imported to the

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application main page, it opens a websocket connection to the interaction server and loads the definitions of the supported LuminAR events. With the communication pipeline established, application developers can create interactive web applications that use vision-based interaction and use kinematics.

What we did not have sufficient time to implement is the code-generation step that automatically creates LuminAR application state definitions for the front end. In the course of this thesis work we hand coded the application states using simple Python configuration scripts, but there is no reason they cannot be auto-generated.

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4 Interaction Techniques

LuminAR was designed to deliver a rich and interactive projected augmented reality user experience. The work in this thesis was carried out in a period of time in which user interface technology emphasis has shifted towards the conceptual realm of *Natural Interaction*.

But, at the same time LuminAR is in essence a projected interactive surface, and therefore it has known limitations such as: lack of feedback from a projected surface, display fidelity in different lighting conditions, occlusions and shadows caused by hands or objects and the need for flat white surfaces. Such limitations many times can be mitigated by interaction design that takes them into account.

While we implemented a simple hand tracking and basic gesture detection mechanism, the next step would be to expand and support full multi-finger detection, multi-hands detection including postures. The technical details of our initial implementation are included in the description of the LuXor software framework Vision Server (see details in chapter 3 - LuminAR). There are many variants in the literature [53], [101] that provide solution to these problems, and they could be adapted to the LuminAR software stack as new modules for our computer vision server.

Natural Interaction

Natural Interaction is an umbrella term that encompasses various known techniques for multi-touch user interfaces; gestural interfaces as well as other sensing based interaction. Such *Natural Interfaces* support *direct interaction*, where the hands or the body serve as the input device, rendering the need for an intermediary device such as a keyboard or a mouse obsolete.

The common denominator for these approaches is the creation of direct, intuitive interfaces that makes our interaction with computers seamless and unobtrusive. *Natural Interfaces* also refer to the interfaces that are able to blend the digital and physical world, while responding to context.

The computer mouse, GUI and the WIMP concepts contributed immensely to the mass adaptation of personal computers. It also contributed to the adaptation of other display-centric computing devices (e.g. smart phones and tablet computers) that essentially used the same interaction paradigm. In the broad sense, *Natural Interfaces* are well on their way to become a key interaction modality in the years to come, and very well may contribute in a similar fashion to the adaption of new form factors for computing that would use augmented reality as key interaction modality. Early evidence of this trend can be seen in the emergence of new standards and major open source

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projects, such as the Microsoft's Kinect SDK [102], OpenNI initiative [103], and work carried out by the Natural User Interface Group [104].

In chapter 2 we outlined some of the challenges that current augmented reality experiences suffer from as they try and provide a natural user experience. In this chapter, we will provide the interaction design principles that guided our work on the LuminAR interfaces. We also provide an overview of the various LuminAR interaction techniques we developed to address some of the current drawbacks. Finally, we propose a set of gestures that take advantage of Kinetic I/O.

Interaction Design Principles

Before diving into the discussion of the actual LuminAR interaction techniques, it is important to review the underlying guidelines they share. Specifically, our design goals were influenced by the intersection of projected augmented reality interface that is also enabled with kinetic I/O.

We summarize below our interaction design principles.

Natural Interaction	Support natural and direct interaction for projected augmented reality interface. Support heterogeneous input modalities
Both Hands are Free	Support immersive spatial augmented reality, namely users should be able to interact with both hands without an intermediate device
No Context Switch	Users do not need to perceive the augmented reality experience through a mediating display. Digital content is directly superimposed on the physical environment
Kinetic / Dynamic	Enable steerable, kinetic interfaces that extend the reach of user interfaces. Support relocating, reorienting and resizing of the projected display
Kinetic / Animatronics	Enable the use of animatronics as a feedback mechanism for user interfaces. It also refers to the capability to track a user or an object in the interaction space
Object Augmentation	Enable the detection, tracking and augmentation of objects using top-projection
JITAP	Enable Just-in-Time-and-Place interactions based on application and user context

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The sections below describe in more detail the principles above, and provide further insights into the actual interaction techniques we developed.

Kinetic Input and Output

Actuated Interfaces

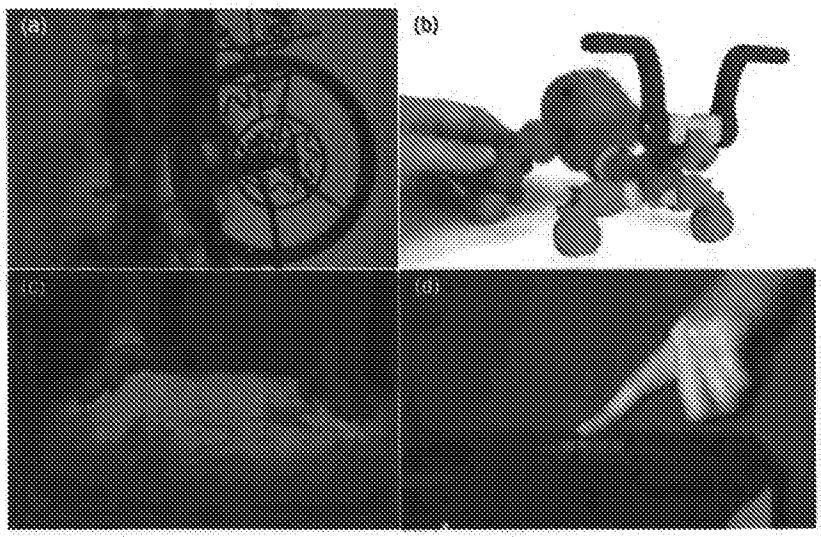
Humans have been developing mechanical motion producing systems for centuries. Examples date as early as actuated set decoration in Greek theater. Nowadays, mechanical actuated toys and robots are very common.

Poupyrev et al defined *Actuated Interfaces* as an interfaces in which physical components move in a way that can be detected by the user [105]. They also specified that such interfaces could employ changes in spatial position of objects, including orientation and position, as well as changes in speed or direction of motion.

The discussion in this section deals with Kinetic I/O interfaces, a subset of the general definition of Actuated Interfaces.

Kinetic I/O

Kinetic interfaces are currently in a very embryonic stage. Although various researchers laid important groundwork for kinetic-interactive systems [106], it is still hard to outline clear interaction design guidelines for Kinetic interfaces, specifically when kinetics meets augmented reality.



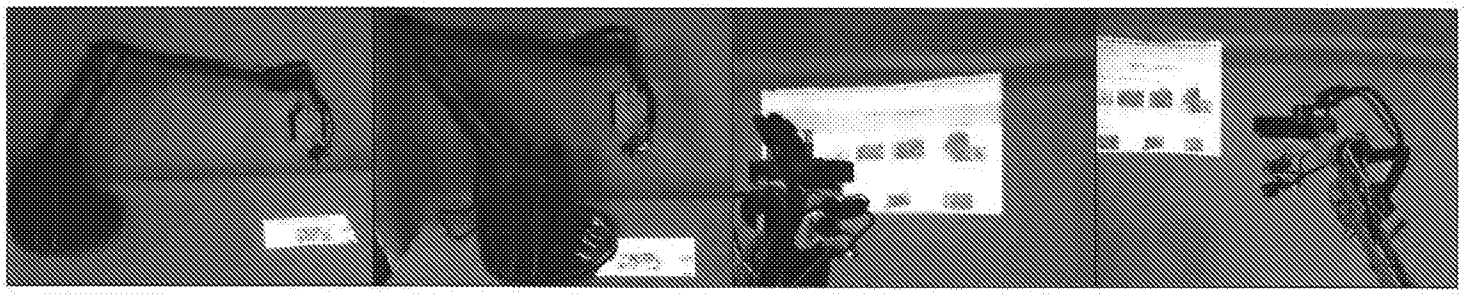
Examples of kinetic interfaces: (a) The Dream, kinetic sculpture by Arthur Ganson (b) Topobo by Hayes Raffle and Amanda Parkes (c) Relief by Daniel Leithinger (d) Lumen by Ivan Poupyrev, photographs by Makoto Fujii, courtesy of AXIS Magazine.

For the purpose of this thesis work, we use the term Kinetic I/O in direct relation to projected interactive interfaces, and in chapter 2 we distinguished the differences between such systems and steerable

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projector-camera. We defined kinetic interfaces as those that have DOFs of their own, this is also the reason that such systems have a new interaction paradigm we call Kinetic I/O. However there are examples for Kinetic I/O systems that do not involve projection or displays directly. One such example is Salisbury Phantom-Based Haptic Interaction with Virtual Objects [107].

The first property of kinetic I/O is simply that interfaces can move, normally in multiple degrees of freedom. As we described in chapter 3, the LuminAR Arms have 4 degrees of freedom that allow to dynamically manipulate the vertical and horizontal position and orientation of the LuminAR bulb. This allows the system to dynamically relocate interfaces easily within the workspace, and increases its interaction vocabulary.



Exploring concepts of kinetic I/O: LuminAR Aluminum is used to alternate the projected display between the wall and the tabletop.

From the user's perspective, Kinetic I/O allows natural interaction using hand gestures to position and manipulate the projected display properties and most importantly the actual content. Based on that general property we propose in the next section an extension to classic *Multi-touch* interfaces; we call this approach *Dynamic Multi-touch*.

Kinetic I/O can also make use of motion to communicate and engage users. Humans can respond well to kinesthetic stimulation, and physical motion can be designed to be subtly expressive and support interaction [108]. Future work on Kinetic I/O may also benefit from adapting concepts like Hoffman's Fluency [109], which exceed the scope of this thesis.

Kinetic I/O holds great potential for projected augmented reality interfaces. This thesis work explores this domain specifically, proposing to enhance such interactive vision-based systems. The reason for that lies in the fact that the vast majority of computer vision based systems are static in nature; this fact limits the viewpoint of the sensor. Kinetic systems are able to dynamically change their perspective; they can track an object or a user spatially and adjust accordingly, specifically since such systems are geometrically calibrated and aware of their 3D position in space, as in the case for LuminAR. These properties can be used to create novel user experiences that have real advantages. For example, imagine an interface that requires object detection. In many cases the quality of the detection is directly influenced by the ambient light conditions, shadows and occlusions. With Kinetic I/O the system can recognize such conditions and respond by shifting the sensor

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viewpoint in order to improve the overall detection score. This capability simply does not exist in static systems, and normally would require a user to manually reposition the object detected.

Finally, using relevant sensing techniques, it is possible for a Kinetic I/O device to respond to a manual back-driving input from the user. Manual manipulation is important since it provides natural means for a user to interact with a system, this is specifically important when interfaces are embedded in everyday objects. It is also important as it provides the system spatial input and context that could be useful for interaction purposes.

Dynamic Multi-touch

Multi-touch refers to the interaction techniques that support direct hands and fingers simultaneous inputs to control computer application graphic content. Multi-touch enabled devices include computer displays, known as "touch screens", tablet computers and also projected touch displays. Touch screen technology is now also in extensive use in mobile devices.

Early examples of multi-touch devices date to the 1980s, when pioneers of the field like Bill Buxton at the University of Toronto developed a multi-touch tablet capable of sensing multiple points of contact [110]. Buxton also provides a good review of the history of multi-touch systems [59]. As multi-touch systems evolved, different hardware solutions were developed, as well as algorithms for finger tracking and gesture recognition. Westerman provides an excellent review in his Ph.D. dissertation [111]. Works like the Bid Screen and SixthSense, represent recent research trends that combine 3D gestures with multi-touch [29], [112].

The main contribution in terms of interaction techniques of this thesis lies in the concept of Dynamic Multi-touch. Dynamic Multi-touch is an extension for the classic gestures vocabulary of multi-touch that takes advantage of a projected kinetic I/O system. Dynamic Multi-touch systems utilize actuated DOFs of the projected touch screen display to support real-time relocating, reorienting and resizing of the projected display.

Dynamic Multi-touch tries to extend the spatial limits of the classic screen bounded interface by allowing it to move, it also addresses the interaction space above the display. In our work we have prototyped several gestures that explore the Dynamic Multi-touch concept. We provide details in the sections that follow.

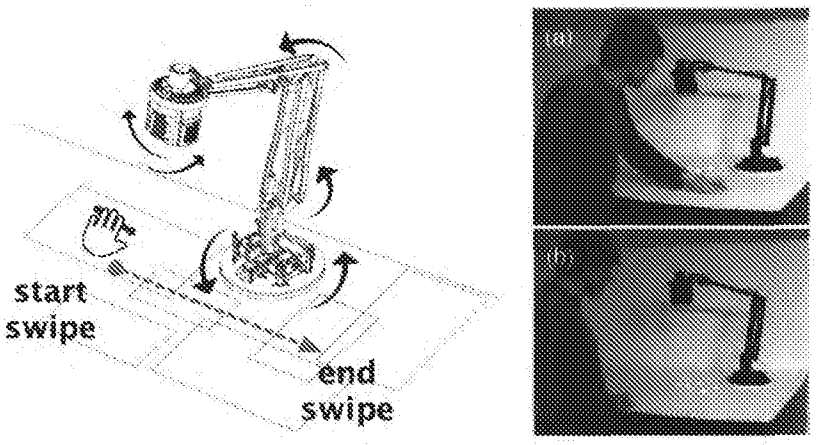
Dynamic Multi-touch Gestures

The Dynamic Multi-touch gestures we describe in this section were initially explored and prototyped using the basic capabilities of the LuXor Vision server modules (see chapter 3 - LuminAR)

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Position-Swipe

One of the basic advantages of dynamic Multi-touch is the ability to position the display. We have implemented a *position-swipe* gesture that allows a user to position the projected display using a directional long swipe motion from a source projection area to a destination projection area. To preform this gesture the user simply selects a start swipe position and begins to move his hand in a steady direction: either right to left, left to right, top to bottom, or bottom to top. The system detects the trajectory of the swipe. The swipe is complete if the user moves his hand away from the viewpoint of LuminAR or if he holds his hand steady under the lamp. The swipe can take advantages of all of the available DOFs of LuminAR. We have used the position-swipe gesture to implement features of the Augmented Desktop applications that we describe in the next chapter.



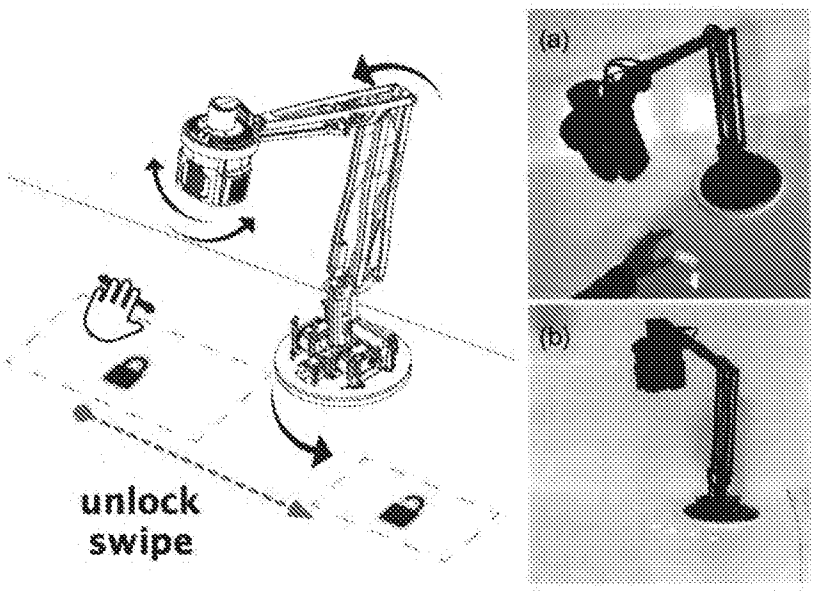
Dynamic Multi-touch: Position-Swipe gesture. (a) A user starts the swipe gesture and preforms a long directional swipe (b) after the user removes his hand the arm follows his swipe trajectory.

Swipe-Unlock

Modern operating systems, normally implement a login screen that serves as an entry point to the desktop metaphor. This holds for PCs as well as to mobile information devices (e.g. smartphones and tablets).

The *swipe-unlock gesture* was designed as an interaction entry point gesture. It builds directly on the Swipe-Position gesture we presented above. The gesture makes use of the animatronic capabilities of the LuminAR system, once the unlock event is registered, the arm can be programmed to perform a motion sequence to alert the user of success or failure of the unlock swipe. When the user swipes his hand under the system, the system responds with a subtle motion combined with unlocking of the projected screen saver.

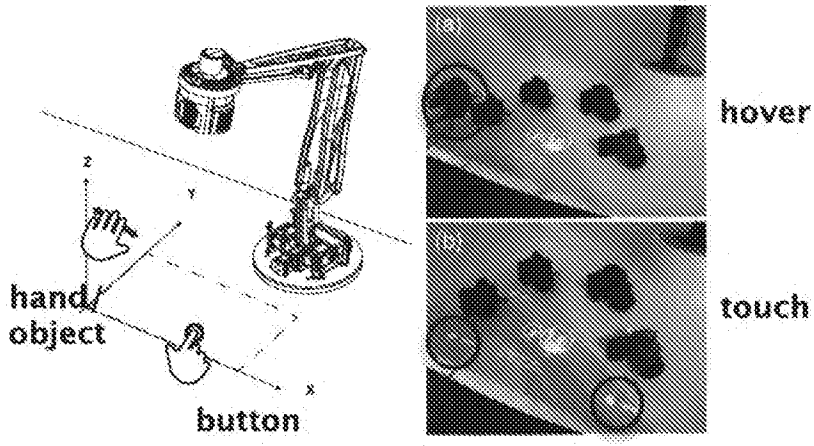
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Dynamic Multi-touch: Swipe-Unlock gesture. (a) A user starts the unlock swipe gesture and preforms a long directional swipe (b) if the unlock swipe is correctly registered an animatronic sequence is activated and the systems' main menu is displayed.

Touch-Hover

In LuminAR's case, classic multi-touch gestures such as button press and swipe are supported using vision based techniques that rely on the homography between the projected display and the camera viewpoint.



Dynamic Multi-touch: Touch-Hover gesture. (a) A user picks up an object, in this case a digital camera. The interaction with the object above the surface triggers contextual JITAP interface (b) that includes projected touchable buttons.

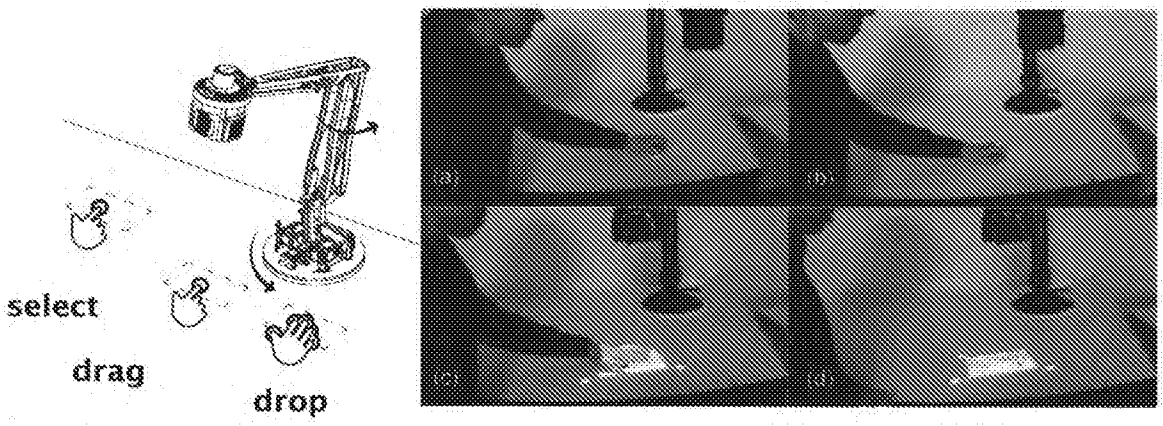
The touch-hover interaction technique uses the same mechanism. It combines object detection or a gesture that is performed above the surface with standard touch interaction that is carried out on the surface. We have used this technique to implement a specific scenario

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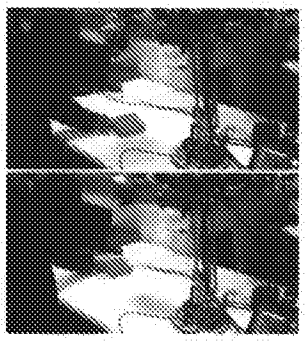
in the Augmented Product Counter retail application (see Chapter 5 – Applications). In this use-case the user holds physical object (e.g. digital camera) above the projection surface, once the object omission from the tabletop is detected, the system provides contextual JITAP user interface. This interface also includes touchable buttons. Conceptually we are combining between interaction with a physical object and digital interfaces. This general concept can be further expanded to facilitate more complex combinations that can make use of the additional Z-axis.

Track Drag & Drop

When we use traditional GUI desktop systems, we take it for granted that we can drag and drop content. We have developed a kinetic-physical drag and drop gesture.



Dynamic Multi-touch: Track Drag & Drop gesture (a) A user selects a virtual object by pressing a button, the virtual object is highlighted with a simple border to simplify detection and tracking (b) the user starts a drag motion using a closed fist, the LuminAR arm tracks his hand (c) when the users decided on a desired drop location he opens his hand and hold its position for about a second (d) the system detects the drop gesture and records the new position for the virtual object.



LuminAR can also track objects; in this example it is augmenting a red box that serves as a tangible email inbox.

The user first selects a virtual object window using a button press or a select gesture; both can be implemented using the LuXor Vision Server modules. Once a selection was made, LuminAR tracks the user hand. We have explored different gestures and found that a *fist gesture* is somewhat natural to use as an indicator for the system to track the users' hand. When the desired location is reached, the user can extend the fist to an *open hand gesture* to drop the content in the new desired position.

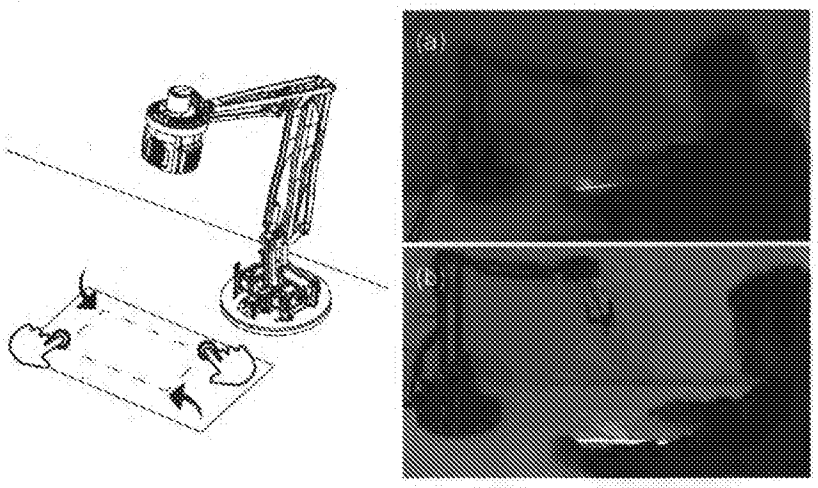
We have used this technique to implement the Kinetic Desktop application we describe in the next chapter. The same technique can also be expanded to a kinetic copy and paste gesture.

Dynamic Resize/Zoom

Multi-touch systems typically enable multiple DOFs of interaction based on the number of detected fingers. But detecting multiple DOFs is not enough; touch display systems also need to support meaningful gestures. Doing so involves sensing a range of touch beyond simple

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touch-points. It also involves direction, angle-of approach and vector information [59].



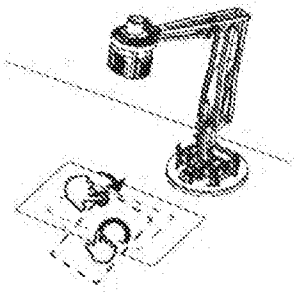
Dynamic Multi-touch: Dynamic Resize/Zoom gesture (a) a user presses down two corners of the projected display, triggering a resize gesture (b) as he swipes away from corners, the arm moves up in proportion to the distance his fingers moved from the original location, causing the projected display to grow in size.

The *dynamic resize-zoom* gesture adds additional DOFs to the arsenal of DOFs multi-touch systems already have. But not in terms of input (i.e. not additional sensing) but in terms of display configuration output. The gestures below utilize the DOF of the LuminAR Arm or Spotlight to dynamically and close to real-time change the geometry, orientation, size and the position of the projected display. It is therefore one of the basic interaction techniques of kinetic I/O as we define it in this thesis.

The dynamic resize operation works as follows: when a user is pressing two corners of the projected content, and generating a motion vector. The vector 2D orientation and scale determine the physical position and size of the projected display. This technique can be used to resize and reposition the entire display, or to zoom on a specific section of it.

Dynamic Rotate

Building on the principle of the *dynamic resize-zoom* gesture, we can design an additional gesture that would support a common orientation change operation that is very common and useful. Unfortunately, we did not have time to fully implement this gesture, but we include its design here as part of the Dynamic Multi-touch possible future gestures.



Dynamic Multi-touch: Dynamic rotate gesture design

This gesture starts when a user is pressing down on a pivot point with one hand, while using his other hand to perform an arc like gesture on the surface. The direction of the arc determines the rotation direction desired. The notion of *pivot-finger* based gestures should be explored further and extended with gestures that support content scaling, navigation and positional directions.

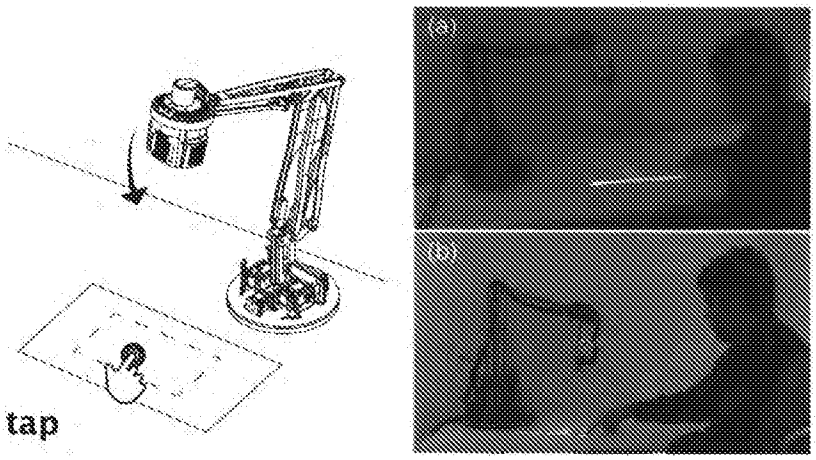
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Tap-Focus

The tap-focus is another LuminAR position-setting gesture, designed to provide the user with a method to position LuminAR. It is a simple gesture, requiring only a tap or a double-tap (if needed) to cause a selection of an area-of-interest that is then magnified.

Double taps can be distinguished from simple button presses using application logic. The LuXor application framework can define software timers and events that can be used to develop application that respond to the different tap events (i.e. double-tap, tap and long-tap).

Optionally, this gesture could be chained with additional taps that would allow a user to easily choose between two zoom levels with just a single tap. This gesture also provides clear and direct kinesthetic feedback, as the LuminAR arm would move according to the user's desired zoom level up or down.



Dynamic Multi-touch: Tap-Focus gesture (a) double taps a point of interest on the projected surface (b) the system responds with focusing the projected display around the location of the tap.

Conclusion of Early Explorations

In this section we have introduced the concepts of Dynamic Multi-touch. We have also included details of the initial exploration we have conducted in our efforts to design novel gestures that use kinetics.

In the informal user testing we have performed, a general pattern of behaviors emerged. Initially, users expected the system to behave like a common touch screen. We can attribute this to the strong presence in 2011 of mass-market consumer electronics that use touch screens. However, and sometime to our great surprise, users were very comfortable continuing to interact with LuminAR after they discovered the touch screen can actually move around the workspace. The majority of our users easily picked up the gestures we described here. Many reported it "felt very natural to use". However, some of users did not respond so well to the fact that a moving robotic arm might potentially

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hit them during the interaction process. Obviously this is a topic of further research.

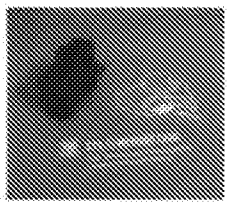
In addition to the gestures that we explored, and based on the feedback we received from our test users, it is clear that additional gestures should be designed to complete the *Dynamic Multi-touch* grammar. The list below contains some ideas for such future gestures:

- Support high fidelity hover gestures that accurately return X, Y, Z coordinates of the arm, hand, and fingers positions.
- Support dynamic hand gestures training and detection (e.g. open-hand, thumb-up, thumb-down etc.).
- Support hover-pinching gestures. Such gestures use a pinch gesture in arbitrary Z height above the projection surface. These types of gestures can facilitate object interaction.
- Support finger tracking in all Z-levels of the interaction space.

The work in this area is still preliminary, and we are in the process of evaluating the merits of this interface formally in the near future. However, our initial results show promising potential that could be exploited in the near future, when depth sensing hardware becomes ubiquitous and small enough.

Just-in-Time-and-Place Interactions

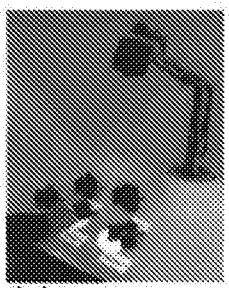
Context-aware interfaces hold great promise for transforming the utility of computing. They encompass the capabilities to detect and react to changes in state of the environment. Without it, computer systems are static and require human-user to initiate and manage all interactions. Understanding context allows a system to respond to a specific user or environmental state accordingly.



Examples of JITAP interfaces in the Augmented Product Counter (APC) retail applications: (1) when the camera is detected we can project a product manual page next to it.

Just-in-Time (JIT) *interactions* are a specific branch of context-aware computing that attempt to enable computers with contextual knowledge to offer relevant information when and where we need it. However 'where' in the definition of JIT interaction refers to how we use computers today, namely via display centric devices and interactions. This means that 'where' is actually on a computer screen window or via a mobile phone's push notification.

LuminAR enables an extension to the classic Just-in-Time interface definition. We are proposing *Just-in-Time-and-Place (JITAP)* interfaces. The notion of 'Place' in our definition refers to a physical location. It is possible for the system to define and recall several locations that embed specific projected information as defined by the user.



(2) Cameras are augmented with price information

For example, LuminAR can be programmed to save and retrieve physical locations for different projected applications. Applications can then be invoked in the specific location when they become relevant, for example: an email application can appear in a fixed location whenever a new message is received.

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Moreover, the system can utilize its animatronics capacity to alert the user. Naturally, traditional UI modalities such as sound and graphics can also be combined to fully complete the experience. The result is a unique actuated ambient interaction.

In chapter 5, we describe how this interaction method was put to work in the case of the Augmented Product Counter and the Augmented desktop applications.

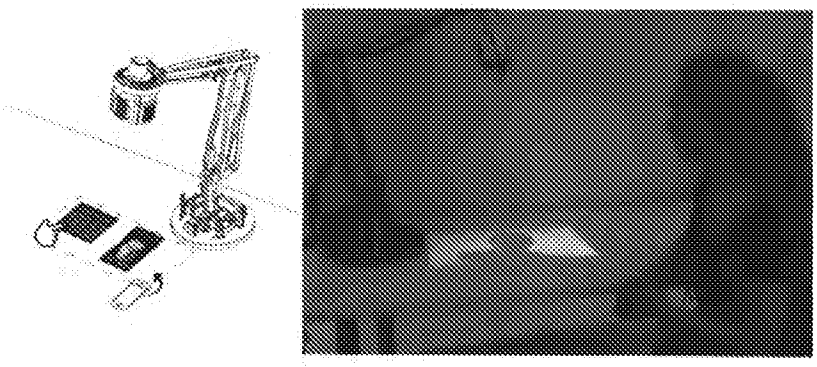
Device Integration

The LuminAR bulb is a wireless computer. It is capable of communicating with other devices in its vicinity, allowing for interaction to extend across device modalities. We have explored cross-interaction scenarios between multiple LuminAR bulbs, mobile devices and laptop computers.

Digital Glue Device

An easy metaphor to think about cross-device integration is to think of LuminAR as a "glue device". It does not attempt to render laptops or mobile phones obsolete, but rather amplifies and complements their use.

According to context, the system can suggest and facilitate data transfer across devices. As an example consider an application where the user is able to physically gesture to the lamp to transfer a document that is currently open on his laptop to the surface next to his screen, yet flat on the desk. This can serve as a virtual stack of documents that is pending, waiting for the user inputs and manipulation.



LuminAR as a "glue device"

For example, consider the case when LuminAR detects a smartphone in the near vicinity. The system can then initiate a wireless data exchange session. The mobile device could then stream an application to the LuminAR device. In the example below we show a calculator application projected on the tabletop. If a call comes in in this mode, the incoming call event can also be projected next to the application while the

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calculator application is still running. Clearly in some cases, it would be desirable to have mobile device content displayed on a large screen.

Data Sharing

The basic notion we have explored is sharing data and context between LuminAR bulbs. In this case we can program the system to form a network between LuminAR bulbs. Applications can then share state data and respond with relevant application content and actuation. A good example of this behavior is described in the next chapter when we discuss the Spotlight virtual retail expert application.

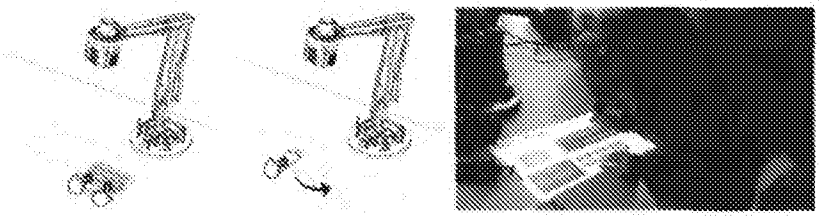
Next, we can clearly identify merit in sharing data captured by the LuminAR bulb between a mobile phone and a laptop, and even between bulbs. Since the bulb software stack uses web-based folders, it is easy to accomplish simply by sharing URLs.

This opens the door for integration with any web application that is relevant for the specific data captured. For example, we can integrate a publishing feature to the Scan Application (see Chapter 5 – Applications), scanned images can be automatically uploaded to an online document services (e.g. Evernote.com [113]).

User Interface Leeching

Not all interfaces were made equal, and not all application scenarios require the same input modalities. This was the guiding principle of a technique we call 'User Interface Leeching'.

Mobile devices and tablets have great input capabilities, and wireless keyboards are great for typing. Since LuminAR is simply a computer it is possible to leech on such input devices and have them function within the context of a LuminAR application.



User Interface Leeching

We have tested such an example of such interaction using a touch enabled smart phone. We used the phone's user interface as a handheld controller for LuminAR. Flicking pages back and forth on the mobile phone touch screen caused content to flick on LuminAR's projected display accordingly.

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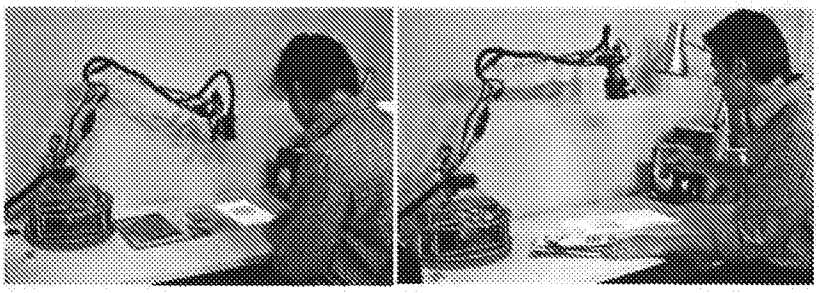
Object Augmentation

In 1999, Jun Rekimoto et al, presented their work on Augmented Surfaces [33]. They contributed several new interaction techniques, among them the concept of object auras. They focused on augmenting physical everyday objects with digital information. Inspired by this work and many others that followed, the LuminAR user interface, vision and tracking abilities enable it to generally augment objects that are in view.

Objects can serve as triggers for the actual desired interactions. Early on in our work we explored how different objects serve as triggers for different augmented content display. For example a printed magazine advertisement could be detected and linked to a special online based video widget that contains further information about the product and an interface to interact with the content, i.e. save as favorite, send to a friend or even order the product.

We also explored this approach in our Augmented Product Counter application, where we augmented cameras with price and feature information. We elaborate further on this example in the next chapter.

Interactions based on physical object augmentation also open the door for many new object-based applications. Detecting and tracking physical objects can help produce valuable metrics, providing insights on usage patterns and user behaviors. This would be desirable for many real-world applications.



Early object augmentation explorations using LuminAR Optimus. The lamp detects objects like a magazine or a can of soda using simple fiducial markers, once detected the objects are augmented with relevant web content.

In conclusion, it is possible to outline how traditional user interfaces map to an augmented interfaces using physical objects. In the list below we describe some examples of possible future augmented interaction:

- Interactions such as ***search, bookmarking, physical copy and paste and annotations*** of printed material (note that this could also work for digital inputs)
- **Physical hyperlinking:** Objects and gestures can invoke web access or email composition. For example if a business card is placed under the LuminAR Lamp

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it can activate the address book application automatically

- **Integrating with passive I/O devices:** For example, if a simple pen is registered by the LuminAR Lamp as the invoking object for a note taking application

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5 Applications

To complement our design and engineering of the LuminAR system, we were constantly and in parallel engaged in creating software applications that test the system, its technical function and overall usability.

We had two areas of focus for our application development efforts; the first was an exploration into the domain of *Augmented Desktop applications*. We created several scenarios that utilize LuminAR in a desktop setting, mainly for information/work related interactions. The second domain we focused on was *Augmented Retail*. We designed a set of novel experiences that use LuminAR in a retail setting; specifically we designed an *Augmented Product Counter*.

Augmented Desktop

Reading, writing and interacting with standard computers are the most commonplace tasks for desktops work, and given the abundance of previous work (which we detailed in chapter 2), it was natural to explore this domain with our system as well.

Part of the motivation for this choice also lies in the fact that LuminAR is unique in form factor, as it is embedded in a desk lamp. It is therefore a form of a digital computer that on the one hand is embedded in your space and on the other hand does not take up "desktop real-estate" like laptop computers do for example.

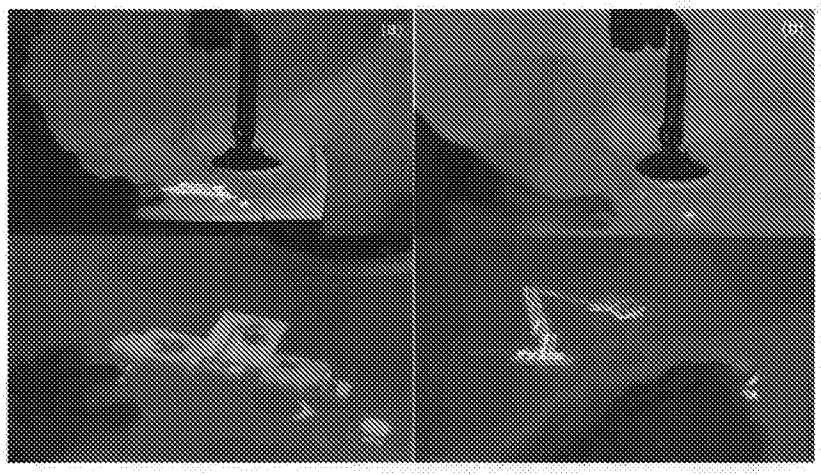
We first focused on familiar interactions with digital media and information, developing projected touch-enabled widgets. However, immediately after exploring standard use cases we shifted our focus to scenarios that blend modalities, taking advantage of kinetics, top-projection and object augmentations as well as LuminAR's networking capabilities. In this section we provide details of the features we have developed.

Projected Widgets

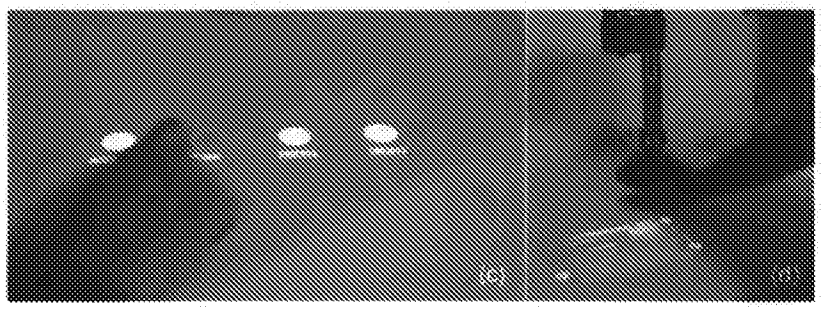
LuminAR's basic use case is to provide an interactive augmented space. To demonstrate this functionality we focused initially on developing a set of general purpose projected widgets capable of performing everyday tasks. We created a picture browsing widget (using a similar technique to Apple's OS X Cover Flow feature), a media player and a scrolling text widget. These widgets also serve as the building blocks for the rest of the LuminAR applications.

As all other LuminAR applications, these widgets are web-based, and designed to incorporate text, video and images. The interaction with the widgets was primarily based on touch events, but also includes hand gestures. For example a user can scroll a large amount of text by swiping his hand under the lamp.

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Augmented Desktop Projected Widgets (a) Cover flow widget (b) Video player widget



(c) Projected touch relocatable menu (d) Scroll text widget that uses hand gestures to scroll large amount of text.

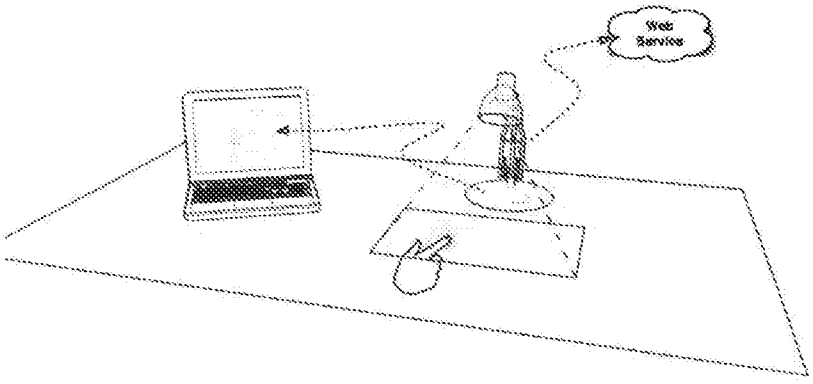
We envision such projected widgets used in standard desktop environments, working in conjunction with a PC. In such cases, the widgets can be used to enhance an existing software interface or serve as an additional contextual display for information. But not less interesting is the case when LuminAR is installed as a standalone object without a computer. We can image having a LuminAR bulb installed in a kitchen and used to augment the countertop.

Following this logic, in one of our early experiments, we explored a concept of LuminAR as a reading lamp. It was used to augment a magazine, enabling digital-physical cross-media experiences. In our example a physical printed advertisement invokes a website that allows a user to watch videos of the product.

Scan Application

The LuminAR Scan application allows users to capture images of objects and projected images on the tabletop. It is designed to provide an instantaneous scan function that does not involve a dedicated scanner or a relatively complex sync with a digital camera.

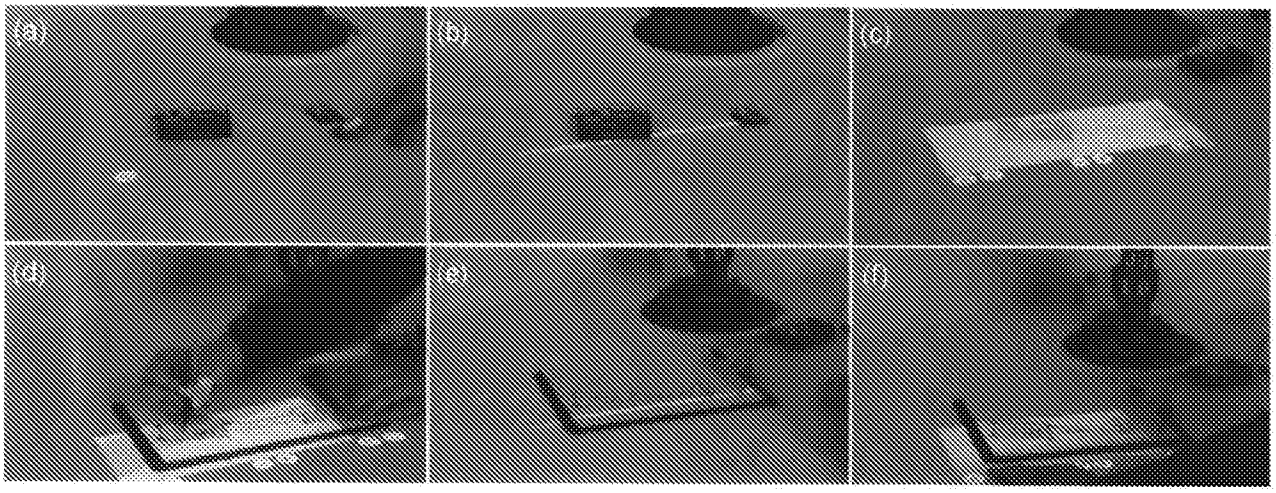
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Concept design for the Scan Application

Using a simple interface a user can place the object under the system and execute a scan. The interface also supports zoom functionality. Once an image is captured the user can resize the result, and project the result on the desktop.

This enables the user to place a different object, and scan again. This interaction design allows the composition of complex images based on multiple scans. We call this technique *Scan-Project-Rescan*.



Augmented desktop scan application: (a) an object is placed under the LuminAR Lamp, when a user hits the 'scan' button (b) the object is scanned, (c) the user can adjust the result using zoom controls, (d) the image can be projected to a paper and (e) rescanned into the system. (f) Finally the user can press the 'share' button to send the image to a web service or another LuminAR device.

Finally, the scan application allows for two different LuminAR systems to share the scanned content. We implemented this feature using a simple web-folder as a destination for posting scanned image results.

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When a share request is executed, we simply point the destination LuminAR to the desired image URL. The Scan App is very simple example of how LuminAR can be used to support remote collaboration. We can imagine how LuminAR lamps can deployed ...

The scan application we developed is a good example for the future of augmented collaborative interfaces. We can imagine how such features create new possibilities for remote communication by virtually sharing a physical desktop and objects while augmenting them with digital information in real-time.

Kinetic-Spatial Augmented Desktop

To fully explore the concept of Kinetic I/O we describe in chapter 4, we designed a novel type of an augmented desktop system that takes advantage of the LuminAR unique interaction techniques. We call this application the Kinetic-Spatial Augmented Desktop.

The application attempts to reclaim the desktop metaphor that was claimed for the digital desktop to a physical desktop. In other words, in our system digital content can be spatially located on an actual desktop thereby blending the physical and digital worlds more closely.

To explore this concept we implemented a location aware menu system. The interaction begins with a main menu entity that appears in an initial entry point location. When subsequent sub-menus are invoked, the projected display will move accordingly to location relevant to the specific submenu functionality. We can program the system to locate a menu according to context, the position of an object or the user's hands.



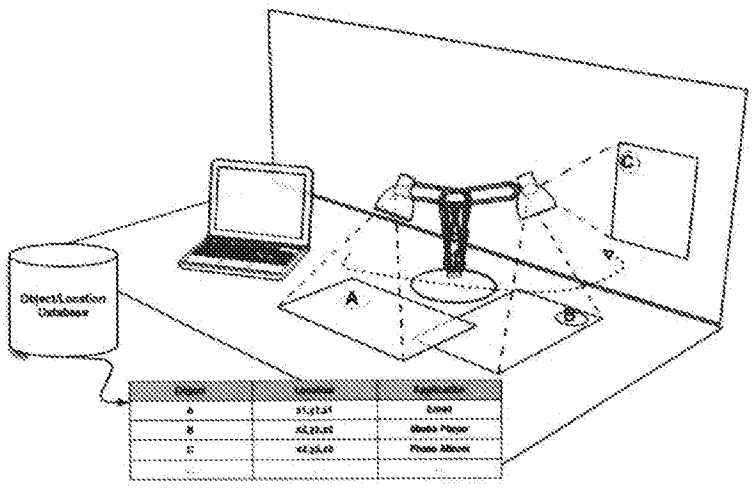
Location aware menu system; top-level menu is projected in the 'home' position. Subsequent sub-menus have their own location relative to the home position.

We used this feature to implement a conceptual demo application that showcases the different LuminAR projected widgets and kinetic demos applications, using our own system for this purpose.

We also designed an interface that allows users to relocate specific widgets in the workspace. Our demo setup included different live web apps that streamed content from the web. We developed a weather

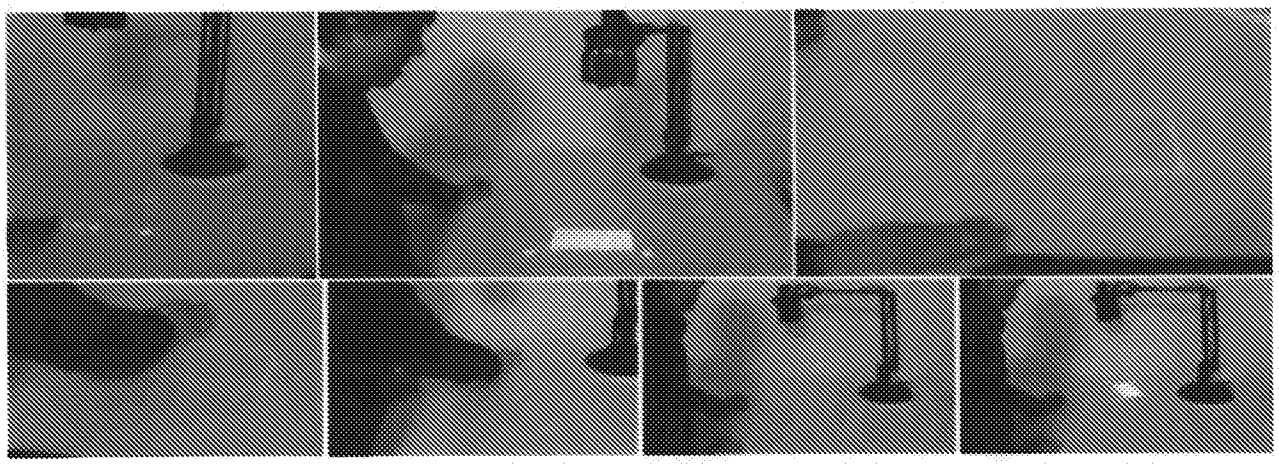
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widget, a YouTube widget and a daily Twitter feed widget. Each widget has a different location assigned in the physical space.



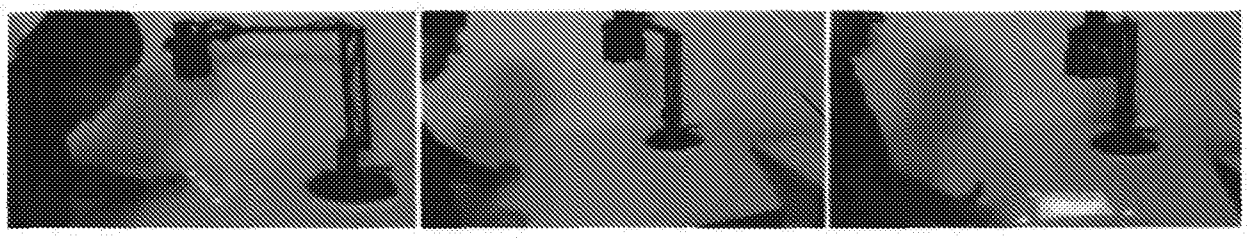
Concept design for the kinetic desktop object/location pairing

The applications were arranged in a dock element, similar in principle to existing application dock bars that are very common in WIMP based operating systems (e.g. Mac OS X or Windows 7). The dock enabled the user to invoke widget and load them to the projected desktop. Once a widget is selected, its location information is retrieved, directing the LuminAR arm to the desired rendering location.



Kinetic desktop prototype; the user can select to move a widget (in this example we show live twitter feed widget) by pressing the 'move' button. Once the widget is selected the user can simply drag the widget frame to a new location in the workspace. The 'drop' can be detected by either removing the hand or detecting a change in the hand posture, for example, a 'fist' could be used to preform the 'drag' function, while an 'open hand' gesture can signal a 'drop' function.

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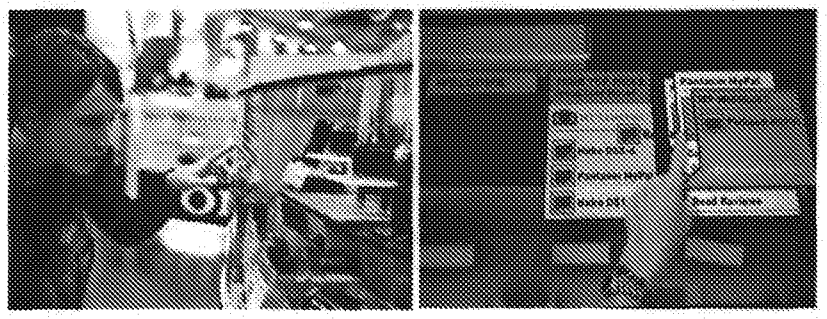
Once a widget is located in its new position, the user can then select to activate a different widget. In this case the user selected a YouTube video widget. LuminAR servos to the stored location for the requested widget and displays it.

The user can then choose to relocate the application by pressing the move button. To implement the relocation function, we developed a drag and drop gesture. The user can drag the application to a desired new location using a drag gesture that is tracked by the system. The actual dragging involves the LuminAR arm actually performing visual-servoing while tracking. Once a desired location is reached, the user simply needs to hold this position for about a second to conceptually drop the application in the new location. Finally, we implemented a swipe-gesture that allows the user to use simple swipe gestures to position the projected display.

This exploration provides a glimpse of the potential for actuated interfaces. It builds on the notion that human cognition is spatial, and therefore kinetic enabled interfaces can possibly assist with tasks that involve information retrieval and recall. For example, future applications can support virtual piles of documents on a physical space stored in different locations.

Augmented Product Counter

The Augmented Product Counter (APC) was developed in collaboration with Intel and Best Buy. Intel provided initial background information for the project with their concept work "The Responsive Store" [114].



Intel's Responsive Store concept – augmented product counter (source: Intel)

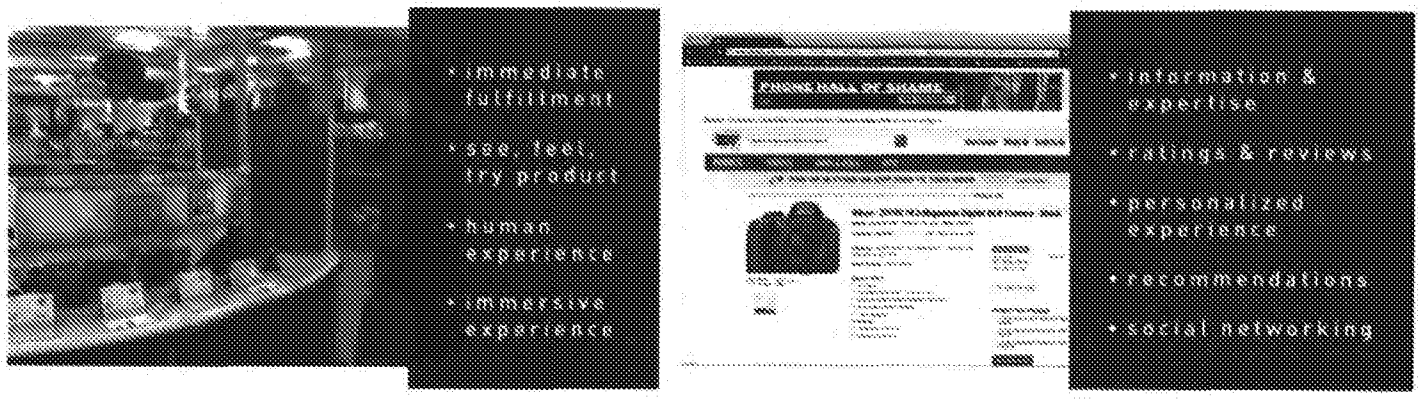
The Need for New Retail Interfaces

In the past ten years, first the web, and soon after mobile devices, generated two tidal waves that disrupted the traditional shopping experience. Shopping transformed into a social process of discovery, powered by tools for comparison, sharing and purchasing. Retailers

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adopted technologies to remain relevant, using the new online channels. However, retailers need to find means to engage customers in physical brick and mortar stores. This concept was also previously explored by Sukaviriya et al [115].

The challenge that the APC project addresses is how could brick and mortar stores evolve to use interface technologies that allow them to remain relevant in an age of online based shopping.



Brick and mortar retail experience vs. online shopping/e-commerce experience

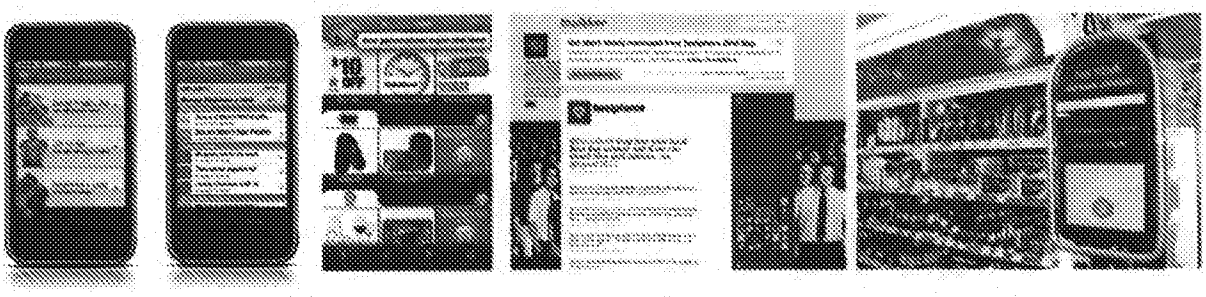
Expert Driven Design

During the design process for APC, the author participated in two MIT Media Lab sponsor workshops led by Prof. Andy Lippman, which revolved around the topic "The Future of Retail". The workshops addressed several aspects of possible solutions to the problem domain we described above including:

- **Making technology easier for the retailer** – Introduction of new inexpensive in-store interfaces that can easily integrate to the backend store management systems.
- **Helping the customer make their decision** through connectivity (be it their home or in the store) – Support the customer in the decision-making process during research at home and while browsing at the store.
- **Connecting with others** – Making a physical shopping experience social, fun and connected.
- **Engaging the customer** in a different way – Steering away from standard static product counter displays to dynamic digital solutions.
- **Customer telling** (product & customer insights for sales associates) – Facilitating two-way communication between a customer and sales associate; allowing customers to reach the most relevant sales person at any given time.

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The workshops, and the ongoing work with Intel and Best Buy retail experts, helped us gain insights into the key challenges facing retailers today. In general, we found that retailers continue to struggle to stay relevant, and must continue and adopt new technologies to remain competitive.



(a) (b) (c)

Examples of new technologies for retail: (a) In-store applications from target, together with shopkick.com who provide a personal deal stream to the user's smart phone. (b) Twelpforce by Best Buy, an online technical help question & answer service based on Twitter. (c) In-store media kiosk for Olay at Wal-Mart.

We summarized their insights in the list below, which served as inputs to our design process:

- **Empower consumers:** The need to design an in-store customer shopping experience that is intuitive and self driven
- **Promote trust:** address the phenomenon of "marketization of information". Customers should be able to trust the retailer with information, so that they do not need to search online or verify the quality of the deal offered. One of the solutions is to fully democratize customer access to information on products in the store.
- **The mobile problem:** smartphones provide customers with means to independently search, compare and even buy while browsing products in a store. As a result, retailers lose business.
- **Costs of labor:** sales associates are the key differentiator for retailers, but they also represent a huge cost item. Customer experience is in fact a highly varied experience based on the quality of the sales associate. In addition, in stores with 1000s of products, associates are not real experts. So there is a need to empower associates and to streamline their work process.
- **Solutions vs. products:** In the stiff competition retailers face with online shopping, selling single products is not enough. For retailers to become profitable they need to sell multi-product packages. These are called "solutions". For example – a camera with accessories such as a memory card, a digital photo-frame *and* a subscription to an online service is considered a solution.

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Field Study

In addition to the workshops, we conducted a field observation study of Best Buy locations. We scouted three locations: Downtown Boston, Cambridge and Minneapolis. In our study we tried to better understand the current physical setup of product display counters, specifically how products and product labeling is carried out. We also documented and observed user interaction with actual sales associates and interviewed them to better understand their work environments and how they engage customers.

The information we collected informed our design process directly, and eventually led us to decide to focus the Augmented Product Counter around digital cameras.



Field study of consumer electronics retail spaces was conducted in three different Best Buy locations, and included observation of consumer behavior and interviewing store sales associates.

Augmented Shopping Concept

To address the needs we discovered, we designed a LuminAR based "Augmented Product Counter". Conceptually, any standard product counter can be transformed into an interactive surface, enabling shoppers to get detailed information and conduct research while they play with the real products. Users can also access the web to read unbiased reviews, compare pricing, learn about product features and talk to an expert who may be located remotely to get additional advice.

The Augmented Product Counter delivers a novel in-store shopping experience that combines live product interactions of physical environments and vast amount of information available on web in an engaging and interactive manner. By engaging shoppers in an intuitive, fun and efficient shopping experience and helping them make informed purchasing decision, this solution can potentially enable retailers to

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differentiate themselves resulting in repeat shopper visits and improved profitability.



Intel's Responsive Store concept – virtual expert (source: Intel)

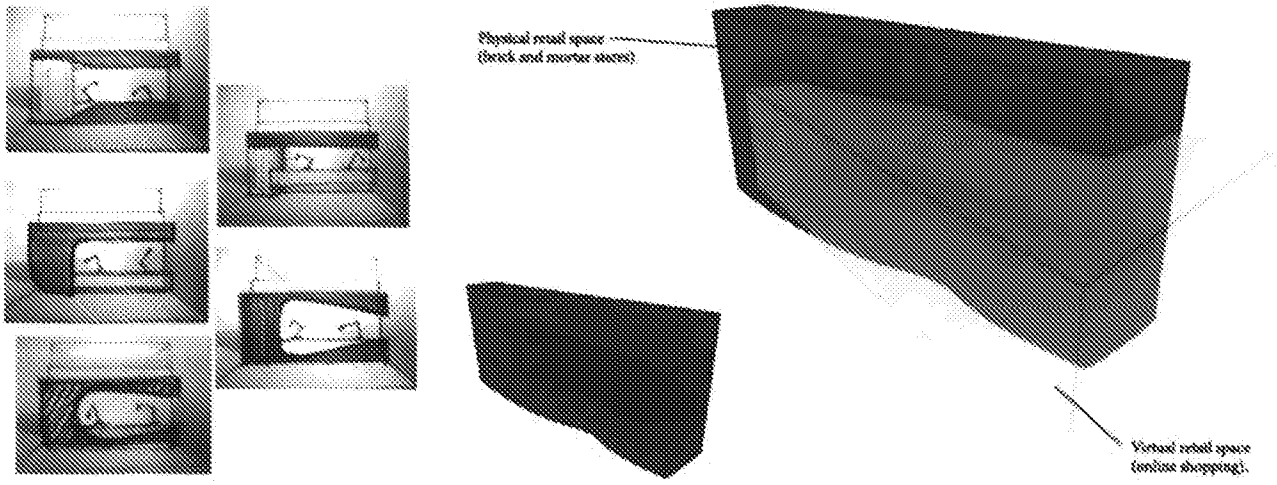
In the sections that follow we delve into the design process, use case scenarios and offer implementation details of the Augmented Product Counter.

Design of a Product Counter

The Augmented Product Counter was designed originally as part of the Intel Connected Store booth at the National Retail Federation Conference 2011 in NYC. We provide more details of this live demonstration in chapter 6.

Concept

Our design was inspired by the analogy of two intersecting elements,

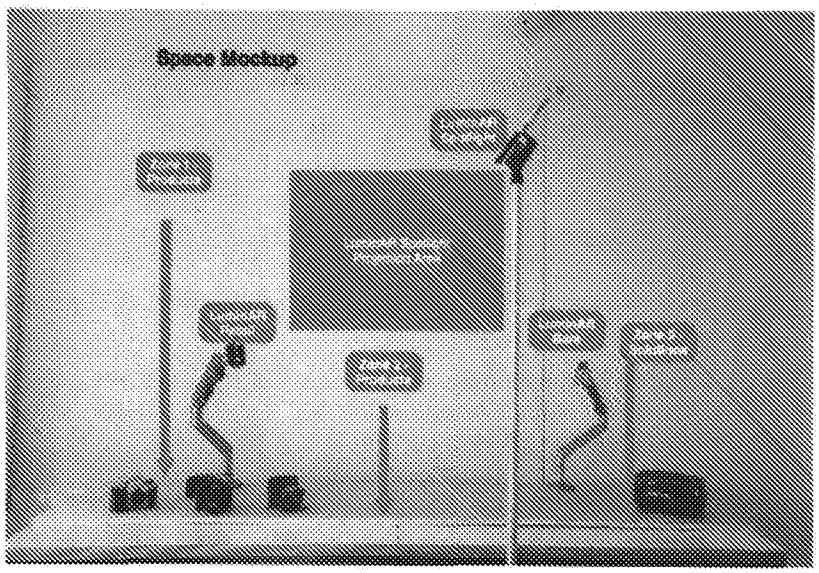


Concept design for the Augmented Product Counter (sketches by Jason Robinson and Yoav Reches)

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one virtual and the other physical. The result provided the design language for the entire counter.

The design concept had strong horizontal proportions, maximizing horizontal space for projection surface purposes. To come up with the required setup parameters such as dimensions, location of the LuminAR Spotlight, ambient light management, we created a mockup space and conducted several projection mock-up tests.



Augmented Product Counter - space mockup design with different interaction zones.

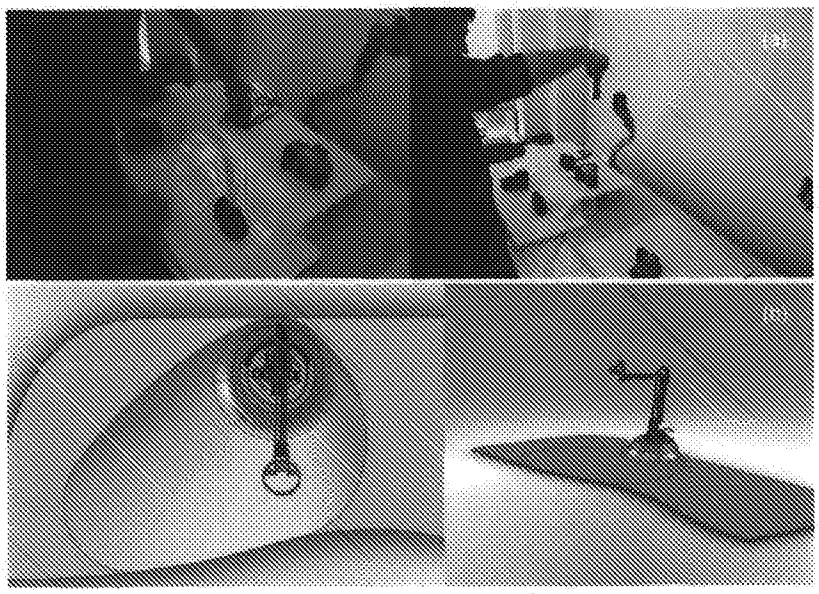
The countertop was divided into three zones:

- **Product display zone:** where all physical products are displayed
- **Interaction zone:** where the user can interact with a specific product
- **Spotlight zone:** a vertical projection space used for the virtual expert session

Multi-level Insert

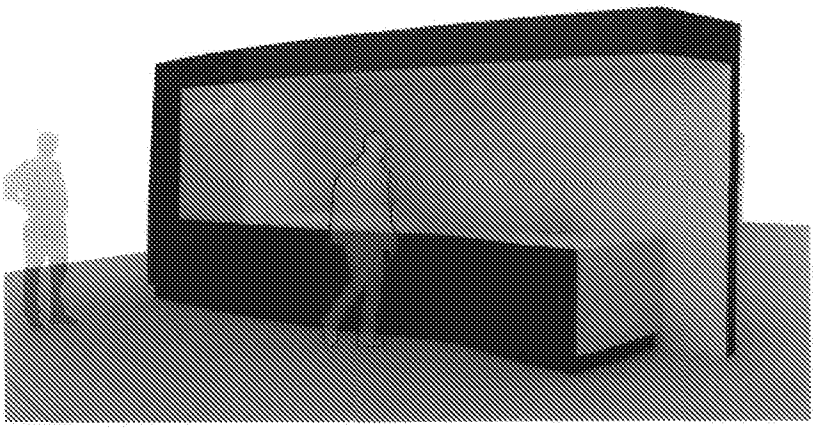
To support the display and augmentation of multiple products, and to allow LuminAR Retail to pivot between the different zones, we designed a multi-level insert element. The insert could accommodate all five cameras on the counter and provided physical soft transitions between the different projection surfaces. The insert was CNC machined, and to arrive at its final shape several tests and designs were carried out.

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Design of the APC multilevel insert: (a) early foam core prototypes (b) renders of the final design

Finally, the design concept matured and detailed process plans were made to construct the final version of the APC. The final design specifications are included in the appendix.



Augmented Product Counter final configuration

Projection Surface Materials

We explored different materials to test their application as a valid projection surface for APC. We were specifically interested in various properties of glass, acrylic and laminates. Clearly, material parameters such as thickness finish and color impact the quality of the projection. In our experiments we discovered that matte laminates provided the

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crispiest images. Reflective and back treated materials had a nice result as well, but with a reduced image quality that blurred with increased thickness. Projection reflective paints are also a good option but require application and are naturally more expensive.



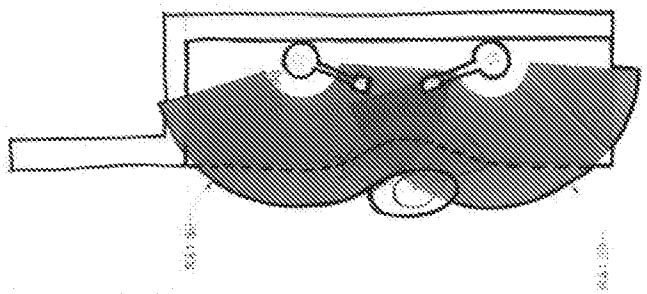
Testing projection materials for the APC counter-top

Interaction Design

This section covers key issues we considered in the interaction design process for the Augmented Product Counter. Overall, both the design and the implementation processes for the APC were highly iterative. Many of the design decision we made came about only after several attempts at prototyping. The documentation and conclusions we present below, can potentially inform similar design efforts for projected augmented reality interfaces in domains other than retail.

Understanding the Interaction Space

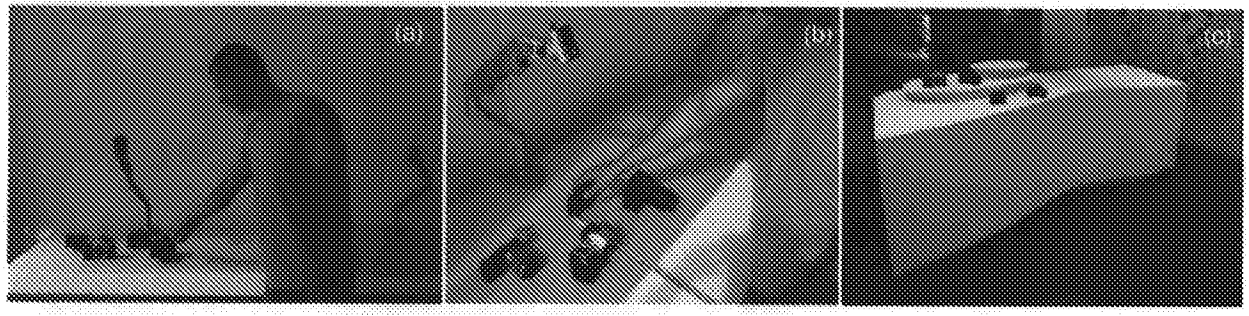
Early in the design process it was important to understand what the physical constraints were we had to take into account while designing the projected GUI for APC. To accomplish this, we used several mockup test projections and made measurements that informed our design process.



Work envelope sketches for APC

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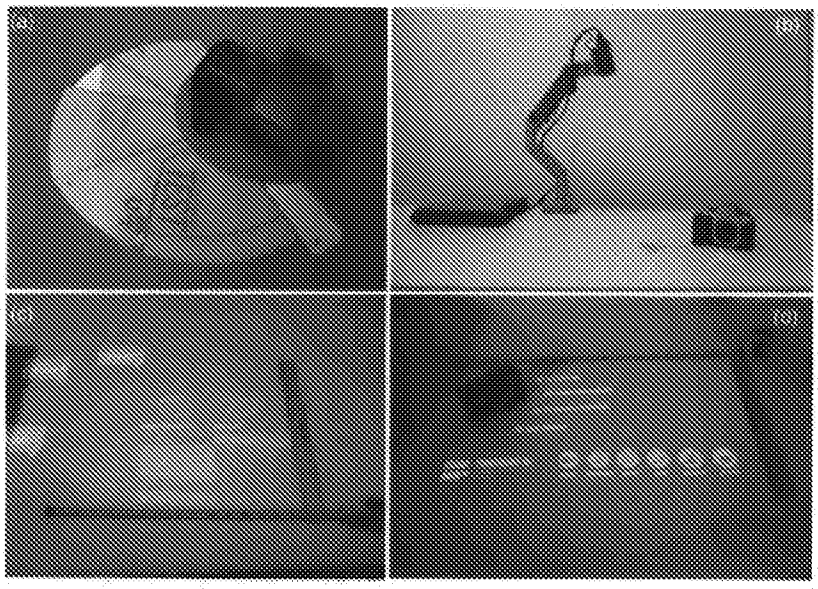
One of the key metrics that was crucial to define for the UI design to complete was the operational envelope of the LuminAR Retail arm in relation to the user. We accounted for parameters like user reach, distance between products, projection angles etc. To fully test our design and integration of hardware, software and interface a foam-core APC model was built and used extensively.



Designing the APC interaction space: (a) measuring users' reach (b) measuring product distribution and projection real-estate (c) the APC foam-core mock up

Projected GUI Guidelines

Creating effective projected user interfaces is not an easy task. The designer must compensate for many elements such as legibility, color-clarity, shadows, occlusions, lighting conditions and so on.



Deriving projected GUI guidelines: (a) and (b) show non-rectilinear projected GUI (c) shows the legibility challenges with certain light colors (c) shows a completed 22" projection using big round buttons, white fonts and bright colors over a black background

We used several different projection test patterns to understand what we can expect from different projection parameters. We also explored non-rectilinear graphics projection, to ensure that the view orientation is always correct regardless of the projection angle. This is a design

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approach for solving the skew and keystone problems projected user interfaces are prone to.

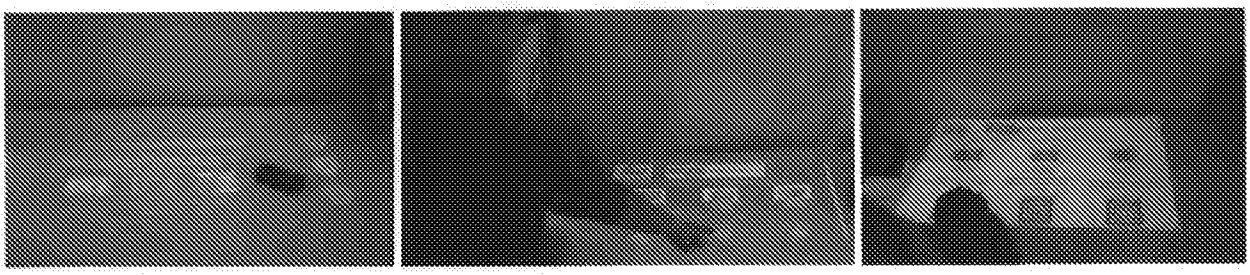
In our design process, through several testing sessions we defined a set of principles or guidelines that can assist in the design of projected user interfaces:

- **Avoid white, pad with black:** projecting white demands the most from the projection hardware, it also takes away luminosity from the rest of the scene, so use it scarcely. However, the color black is your friend. Generally, Using black to pad and outline your GUI elements will result in a clearer and brighter projection.
- **Design for dynamic scales:** projected UIs need to be able to scale dynamically with respect to the projected screen size, specifically when the projection setup changes. This is very common when the system is kinetic (e.g. in LuminAR's case)
- **Use non-rectilinear graphics:** this is a design approach to avoid handling complex image skew and keystone correction
- **Minimize shadows and occlusions:** place UI elements as much as possible in locations that minimize the chance that users would reach out and occlude the interface, typically the edges of the projected screen
- **Use big and legible fonts:** always test fonts as a function of the projected display. We found that for 20" display at WVGA resolution fonts less than 16p would render poorly

Software Development

The APC applications are specific LuminAR apps running on top of the LuXoR software framework we described in chapter 3. The applications were developed in several iterations, working progressively to improve interaction and graphic content.

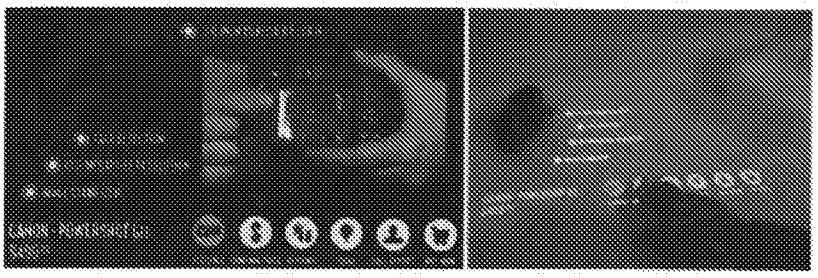
Our early exploration involved rapid prototypes, using the Best Buy Remix API [116]. Quickly afterwards, we created elaborated interaction flow designs that described a full demo scenario for APC. We include the full scenario in the appendix.



Early software and GUI exploration for APC using Best Buys' remix APIs

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The final GUI of APC was fully developed using web technologies, namely HTML5, CSS3 and Javascript.



Final APC GUI look and feel

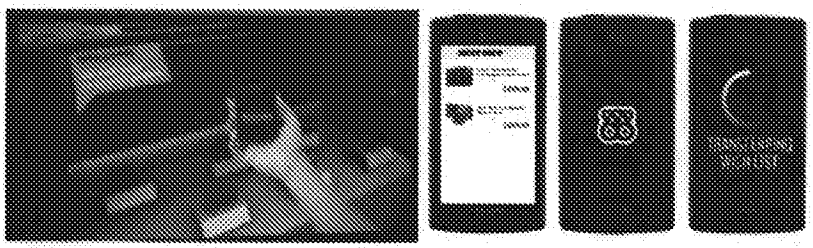
Use cases for Augmented Retail

In this section, we describe the actual use cases supported by the APC, their design and implementation. The general design requirement called for users to be able to interact with the products on display and receive just-in-time information based on their pre-existing profile, market research or store pushed data. Users are able to use their mobile phone or simply login to the system. We employed gestural and multi-touch interfaces as well as augmented reality techniques to support various use cases.

In the sections that follow, we will discuss the entire APC user interaction flow.

Interaction Entry Point

The APC interaction entry point involves being able to identify a customer and access his personal shopping preferences information. Such information may include standard personal information but also product wish lists.



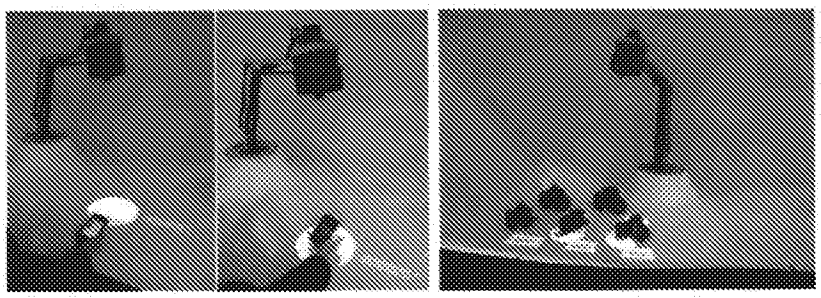
(a) (b)

APC interaction entry point is a mobile phone application. (a) Shows the concept of logging in to the counter display. (b) Shows a sequence of the APC mobile applications.

To facilitate a "login" to the system a user could simply use his mobile device. In our implementation we used a Samsung Galaxy I Android handset. We developed a mobile shopping application that provides the user with a unique fiducial marker identifier. To start interacting with the APC the user simply scans this marker under the system. The

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system then connects to the shopping profile and retrieves relevant wish list information that is displayed directly on the products.



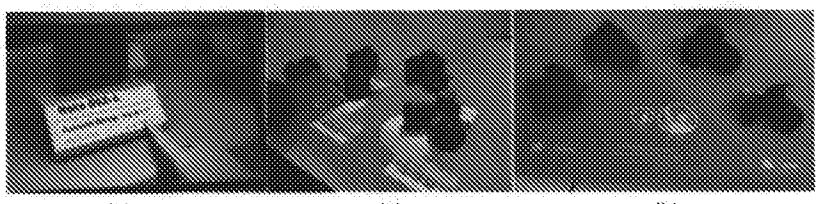
(a) (b) (c)

(a) When a user approaches the APC, he can use a mobile application to browse his profile and wish list (b) the user can 'login in' to the APC by scanning a ficucial marker from his phone, that serves as a personal identifier (c) once the login is complete the APC reflects the users wish list by augmenting the products on the counter.

Contextual Product Browsing

When consumers are searching for a new product they naturally flag products they are interested in, following suggestions from retailers or other customers. They also consult with their direct social network for family and friend advice. Before a purchasing decision is made, consumers spend time reviewing product specifications, comparing it to competing product alternatives, and reviewing other factors like warranty and shipping costs.

The APC provides a contextual product-browsing interface. By contextual we mean that information and interfaces are displayed in response to a certain user interaction with the product. For example, when a customer picks up a product from the counter's product-display zone, just-in-time information is displayed directly "under" the spot where the product was displayed on the counter. Such information includes key feature information. For example, when the user picked up the Cannon G11 camera, the face recognition and optical features are highlighted.



(a) (c) (b)

Contextual product browsing with Just-in-Time-and-Place information: (a) Design from Intel's responsive store concept. (b) When a user picks a product from the APC, (c) contextual information is displayed directly underneath the product.

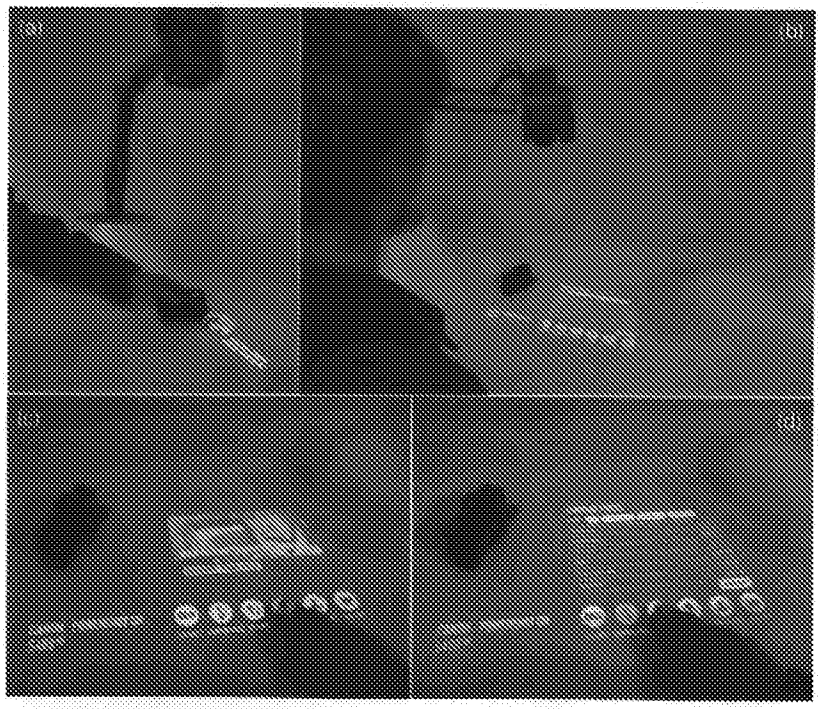
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The APC constantly monitors which products are currently not on the counter, thus making the implicit assumption they are currently in the customer's hand. Using a timeout mechanism the system infers that since the user is spending a substantial amount of time inspecting a product, he would be interested to learn more about this specific product. In such case the LuminAR Retail arm servos from the product display zone to the product interaction zone. This is an example of using the kinetic behavior to create a more engaging experience and encourage the user to interact with the product.

Product Interaction Zone

The product interaction-zone provides a simple cue for the user to place a product of his choice in a projected target zone. Once a product is placed in the target zone, the interaction-zone becomes alive with information. The interface updates, real-time information such as:

- Price comparison
- Product rankings
- Special sales
- Video manuals



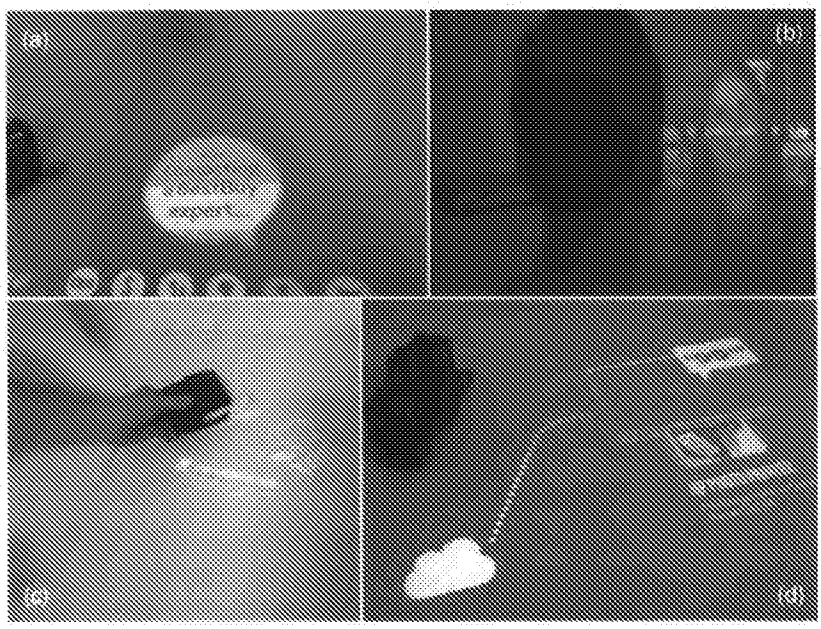
APC Product Interaction Zone: (a) The user places the camera in the product interaction zone (b) An online shopping experience is projected around the camera (c) control product features information video (d) in-store price comparison.

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Remote Expert

Earlier in this section, we mention the labor problem retailers face. The APC tries to address this problem by introducing a remote expert function. The basic idea was to support both the customers and the staff of the retailers, by giving them access to an associate that can be remotely located.

This functionality used the LuminAR Spotlight form factor, to enable a two-way video teleconference between a customer and a virtual associate. The remote expert can provide product usage examples and manuals, augmenting the interaction-zone surface visible to the customer and also answers any questions that come up. The expert could also potentially see the customer using the tilt webcam in the bulb, although in the current APC implementation we did not fully implement this feature.



(a) A user can start a teleconference with a remote virtual expert by pressing a bution (b) the expert can answer product questions but can also recommend additional products (c) the expert can re-augment the counter with information relevant to answer the customer's question, in this example the expert is displaying a manual page (d) The expert can also push additional information about complementing products to the camera the customer is enquiring about.

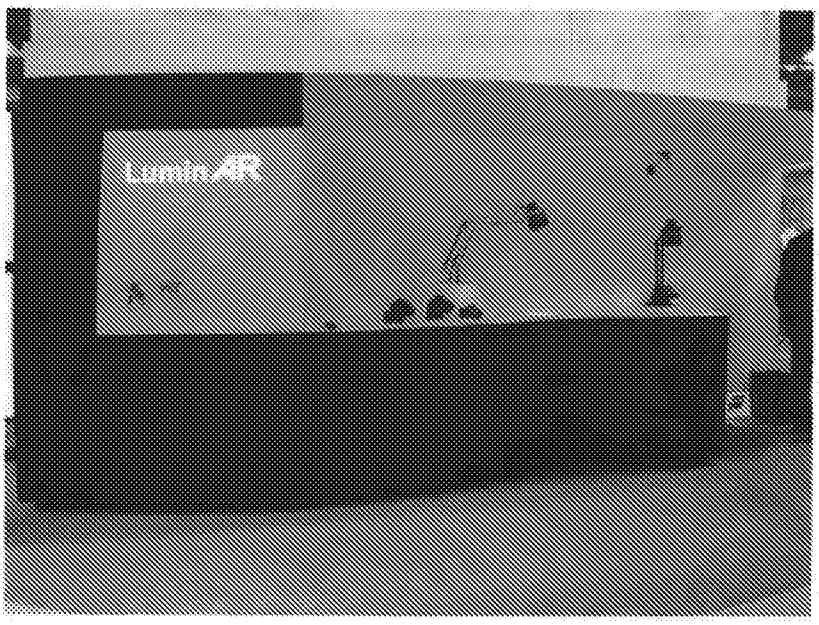
In the example scenario we have created, we focused on the customer side interfaces, developing capabilities to push product manual pages as well as additional information about complementary products for the digital camera, such as printers and digital photo frames. This remote augmented reality scenario, can potentially help retailers create actionable sales, but also effectively optimize labor resources.

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Conclusion

In this section we presented the Augmented Product Counter concept. We explored how LuminAR can be utilized to revitalize the traditional retail experience, providing an enhanced shopping experience for consumers in physical stores.

The demo scenarios we explored show how interactive and persuasive interfaces can be used to engage customers. The APC also proposed a design for fluid transitions between online shopping to actual physical product browsing in a store.



Augmented Product Counter at NRF 2011, NYC

For retailers, the APC provides insight for the application of augmented reality as a valid in-store technology. The APC builds on today's familiar web and mobile-enabled consumer behavior. Such intuitive and connected interfaces could contribute to increased engagement of customers in the store. Allowing users to freely search and explore products will potentially increase the trust between a customer and a retailer, potentially directly contributing to more actionable sales, cross-sales, and opportunities to up-sell products. It can also help support the retailers' workforce, enabling staff to answer questions and sell like experts and provide real-time metrics.

For further details on the APC, we have included additional information regarding the application flow, software and GUI in the appendix.

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6 User Experience

While a formal evaluation of the various LuminAR systems and components has yet to be completed, the work has been presented and tried by public audiences on several occasions. The reason such an evaluation did not take place is the author's personal opinion that it is too early for the system to undergo formal usability evaluation, and that the results of such evaluation may not contribute to the further development of the system at this point. Some of the reasons to avoid the evaluation at this point were well captured in Lieberman's work 'The Tyranny of Evaluation' [117].

More recently, Greenberg and Buxton published a critical paper: 'Usability Evaluation Considered Harmful (Some of the Time)' [118]. In this paper they outline how in some of the cases usability evaluations are inadequate, in particular, in the early design stage they add little value but can also squash what could have been a promising idea:

> *"Yet evaluation can be ineffective and even harmful if naively done 'by rule' rather than 'by thought'. If done during early stage design, it can mute creative ideas that do not conform to current interface norms. If done to test radical innovations, the many interface issues that would likely arise from an immature technology can quash what could have been an inspired vision. If done to validate an academic prototype, it may incorrectly suggest a design's scientific worthiness rather than offer a meaningful critique of how it would be adopted and used in everyday practice."*
>
> *— Saul Greenbreg and Bill Buxton, Usability Evaluation Considered Harmful (Some of the Time)*

Although, the LuminAR prototypes are fairly advanced, they are still very much 'lab prototypes'. The operation of the system is dependent on the research team, and the system is not robust enough to be fully tested by users without injecting subjective bias into the actual evaluation protocol.

Therefore, relevant formal evaluation of the LuminAR system should be postponed to a point in time when: (1) the system interfaces mature and stabilize for ongoing independent operation by a user and (2) a clear and comparable evaluation for a specific use case be devised such that it can provide valid and reproducible results.

Demonstrations

This section contains the feedback and observation we collected during the various LuminAR demos.

Media Lab Sponsor Week Spring 2009

The first public demonstrations of LuminAR took place during the MIT Media Lab Sponsor week in Spring 2010 (May 25-27, 2010). We

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presented a conceptual prototype that included early versions of the robotic arm as well as the LuminAR bulb. The demo scenario was scripted and controlled, but we were able to demonstrate conceptually the potential of a kinetic projected interface. We choose a simple augmented magazine application that mixed digital content that popped up next to a physical magazine. We also mocked up a just-in-time-and-place email application. Visitors were very interested in the interaction capabilities of the system, and often attempted to interact with the projected content during the demo. We received an abundance of suggestions for possible use cases.

UIST Conference 2010

A demonstration [3] of LuminAR was given to approximately 200 participants of the UIST 2010 conference (October 3-6, 2010). About 50 of them briefly had a chance to experience the interface themselves, and it is safe to say that most of the participants were HCI practitioners.

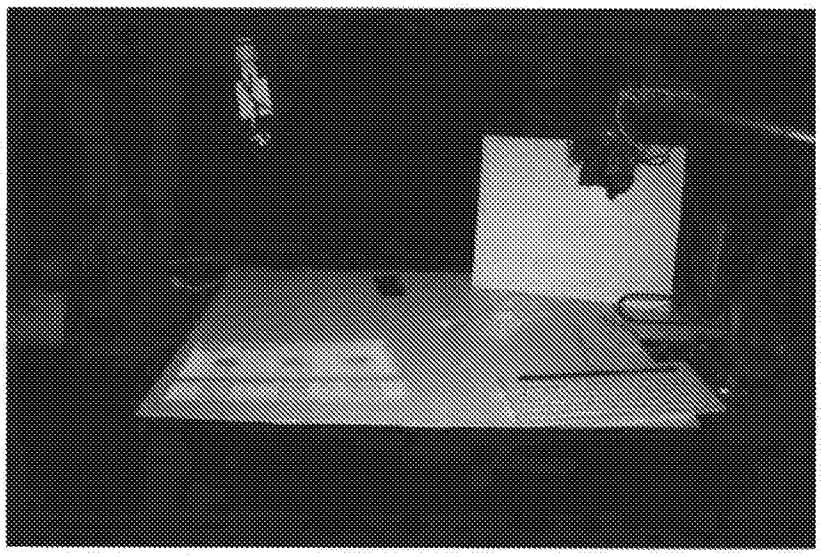


Figure 121. LuminAR Aluminum and LuminAR Tipsy prototypes at UIST 2010, NYC

We presented two LuminAR systems; the first demo was of LuminAR Aluminum model running a retail scenario experience prototype. The scenario included downloading product information from Best Buy APIs and providing a projected online store experience. Interaction was supported using fiducial markers as a quick means to prototype interaction. The second demo was a hardware demo that presented our latest design of the LuminAR Tipsy model. This model had proportions and design aesthetics closer to an Anglepoise lamp. It also had the first fully implemented bulb prototype that could rotate. The Tipsy model was mainly used to shown the kinematic capabilities of the new hardware, including the new motor system that was implemented as well.

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This demo was also served as a good test case for relocating the LuminAR setup from one location to the other. The lamps were easily put in a box and set up at the venue. We did not require any special calibration to get the system working in the new location, even though the ambient conditions were very different.

Reaction to the concept and implementation of the system were very positive. The idea of a small-scale steerable system seemed compelling to most of the people who actually interacted. Many mentioned the value in a compact projector-camera setup. We have received critical feedback on our interaction techniques, as our demo included basic fiducial marker based interaction. In later versions, we have upgraded our vision server and implemented hand detection mechanism based on the feedback we got.

Media Lab Sponsor Week Fall 2010

The MIT Media Lab Sponsor week in Fall 2010 (October 14-16, 2010) demo was similar to the UIST 2010 conference demo as they were only a week apart. However during the open house demonstration we received additional feedback regarding the interaction and potential use cases. For example, as we were presenting the retail scenario for cameras, representatives from the Lego Company suggested unique LEGO Brand augmented store experience:

> *"Jonathan is now 8 years old. He loves LEGO and is very much into LEGO Star Wars. For his birthday Jonathan received a long wished for LEGO Star Wars box and now he is visiting his favorite LEGO Brand store to try out the new AR Build experience. With the box under his arm he is walking towards the AR Build area with steaming expectations. As soon as he puts his LEGO box down on the table Star Wars images and icons are appearing on the table surface around the box and the voice of Yoda bids him welcome: "Begin the challenge we must do". Jonathan opens the box, empties the bags out and puts the building instructions aside for later – now it is time for AR Build! The first bag to build from is highlighted on the table and beside it an Obi Wan Kenobi mini figure jumps up and down eager to help. Jonathan opens the first bag and start building from the instructions shown on the table surface. He can easily flick through the building steps and even zoom in and out using his fingers. On the way Obi Wan is trying to help finding bricks and giving tips. Now the first spacecraft is done and an animated game starts in front of Jonathan. With the spacecraft he must avoid an asteroid storm -Obi Wan is jumping and cheering at the side. Mission accomplished– time for the next model build. Jonathan notices that a girl has entered the AR Build space beside his. She is building a CITY Police station and a small mini figure policeman helps her out. Obi Wan seems a bit distracted. He runs over to the policeman and they start a little argument. The policeman wants to arrest him, but in the end they become friends and set up a little challenge for the kids to solve. Jonathan and the girl look at each other and laughs. Jonathan thinks...oO(This is fantastic – I will*

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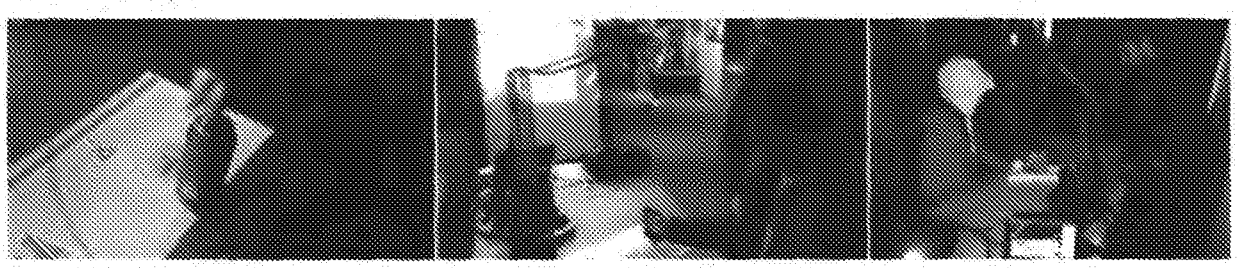
never forget all this when I play with my new LEGO at home. I can't wait to get to school tomorrow and tell about it!"

—Technology Product Manager, Electronics R & D, LEGO

We received additional concepts from different industry sponsors in various domains such as banking, gaming, office furniture and more.

Light Expo at the MIT Museum 2010

LuminAR was also featured in the opening celebration of the MIT Museum Light Expo and the Luminous Window 2011 exhibition (December 10, 2010). The crowd included about 50 children in various age groups who were very interested in playing around with the new interface. For this demo an application that responds to physical objects was created. Its main feature was to browse the web, based on association with physical objects. For example, a Coke can would bring up the Coca-Cola website. A mobile phone was integrated as a browsing interface, flicking through images of fiducial markers would change the website displayed.



LuminAR @ the MIT Museum Light Expo 2011 (photo credit: Monica Brandt, Mark Ostow Photography, source: MIT Museum)

The children who experimented with the system immediately understood the basic touch-based interaction and how they can use it to change web pages using the mobile phone. They all asked the same question: "do you have games we can play?" Gaming indeed seems like a good potential domain for future LuminAR applications.

NRF Conference 2011

As a result of a research collaboration with MIT Media Lab sponsors Intel and Best Buy, LuminAR was showcased prominently in Intel's booth [119] at the National Retail Foundation (NRF) 100th Annual Convention and EXPO in New York City (January 10-11, 2011). The conference attracted over 22,000 retail professionals, and The EXPO Hall was an enormous 150,000 sq. ft. with more than 500 vendors [120].

The LuminAR Retail demonstration included a rich augmented retail scenario, including physical product augmentation, integration of rich e-commerce features and the LuminAR Spotlight remote expert feature.

The response from the professional retail crowd was very positive. It seems that the LuminAR experience may answer real concerns and challenges the brick and mortar retail experience suffers from, namely the loss of customer base to online shopping. By bridging the physical

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and digital experiences in a retail environment, retailers can have the best of both worlds.

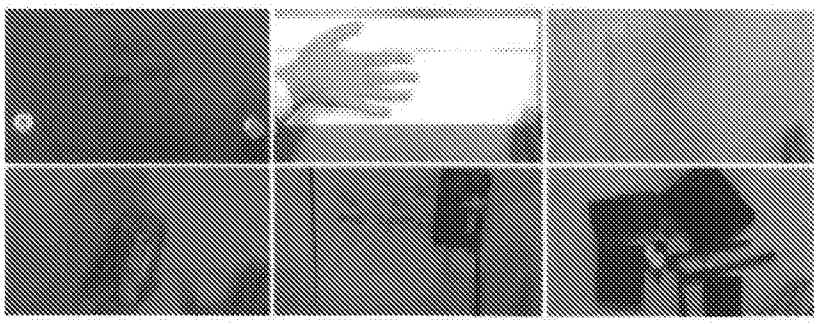


Several LuminAR Retail and LuminAR Blackjack demos took place at NRF 2011. LuminAR was featured in Intel's booth

The retail professionals also voiced concerns they had adopting such technologies. Some were skeptical regarding the need for actuation in a retail setting, arguing that much of the interaction we created could be done without kinematics and that a moving system may confuse the customer in the store. Other issues included the ease of integration and fidelity and resolution of the display with respect to the actual projected display size. All of these issues are indeed important and should be considered if and when LuminAR technologies migrate from the lab to the real world.

Media Lab Sponsor Week Spring 2011

During the Media Lab Spring 2011 sponsor week (12-14 April, 2011), we presented the NRF 200 demo, as well as new the new Augmented Desktop demos using the LuminAR BlackJack and LuminAR SilverJack models. This was the first time we demonstrated the *Kinetic Application Dock* and *Augmented Scan Application*. We had about 20 visitors experiment with the system after a short tutorial. Many of them had no problem interacting with the system. However, we did receive feedback on the responses for the touch interaction. The *Scan Application* received extremely positive feedback as many visitors mentioned that it eliminates the need for proper scanner hardware to some extent and can prove a very relevant use case for LuminAR in the future, specifically due to the collaborative potential of the application.



Results of sponsor week open house visitors playing with the LuminAR Blackjack scan application.

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User Experience Feedback

We have collected the feedback received from individuals who had a chance to interact with the system, and tried to solve immediate issues. Many of the suggestions and feedback we have received in the various demonstrations were implemented during the different project iterations.

For example, we include below anonymous responses from our informal user study participants:

> *"I think it fills an interesting need, and when integrated with physical displays can help create a more immersive shopping experience..."*
>
> — ***SVP & General Manager New Business Customer Solution Group, August 9, 2010.***
>
> *"It is very good, interesting, adaptable to the environment. I can imagine it placing in store. One of the thoughts I have is for operations, with doctors, health related function such as perspiration medication distribution. There is no need for tablet (that we use now), we can just project on a wall or other natural places. It should have a quicker response time and possibly a higher-resolution, though for some case this is just good enough."*
>
> — ***Marketing Director, February 2, 2011.***
>
> *"The augmented shopping scenario shows a very creative interface applied to shopping. Coordinating the projector motion, camera recognition, and content selection was a big job, I'm sure, but it came together really nicely to show the power of the system. I can see this LuminAR approach also having important application in education."*
>
> — ***Director, Advanced Technology, March 2, 2011.***
>
> *"For me LuminAR was really fun and engaging. It was slightly confusing sometimes, mostly due to some of the inconsistencies/bugs in the tech... like when things didn't read location of taps properly, and not at all a problem with the design. Even with the few examples we saw (for example taking picture of the desktop) there was this quite *magical* feeling that the entire desktop was your digital oyster (that any flat surface underneath the cone of the projector could become anything else) and it was wonderfully tactile in that way. I wonder what would happen if we got to incorporate tangible tokens into the interaction? It was interesting that the actual projection moved around due to the lamp arm. At times this was confusing ("ahh! where is it going???!") and other times it is ridiculously engaging, since the interface is essentially a spotlight that hypnotizes you with moving information... so you can't help but follow it with your eyes. The idea of directing attention/focus through LuminAR sound particularly interesting..."*
>
> — ***Graduate Research Assistant, MIT, August 8, 2011.***

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"I've used touch-based interfaces, and several different forms of augmented reality interfaces, but the experiences I had with LuminAR were singularly different. Gesture became bidirectional and surprisingly informative—anthropomorphic gesturing robots feel a poor imitation of the human social fabric, but here is a new kind of partner, for play or work, freed from the demands imposed by our genetic heritage."

— ***Graduate Research Assistant, MIT, August 8, 2011.***

"At first looks, LuminAR made me immediately think about places I personally have my own LuminAR installed and physical interactions that are now becoming possible. (For example I thought about my bedside reading lamp that can turn a blank page of paper to my e-book without having the risk of breaking it when I was falling asleep, same as for the kitchen space and my work environment). What I liked about LuminAR is that it is generic enough to support many communication needs and present information in a very non-generic and non-conventional way tailored to different use cases in the real tangible space. When experiencing the retail space demo with a virtual sales representative I started to think that LuminAR can enrich our current internet based communication with a parallel (optional) layer of communication that the website adds related to me personally and the context of the page. I was a bit frustrated with the fact that the tactile feedback is still missing from this concept but it is understandable as these limitations may be inherent to many augmented reality concepts."

— ***CTO, Advanced Technology Lab Director, August 3, 2011.***

"LuminAR is at core a smartbulb with built-in display plus camera which seamlessly projects a fluid applications experience onto ordinary surfaces – including tabletops, walls, floors and others – thus turning these otherwise static spaces into as rich an applications ecology as you find on your smartphone, and perhaps more so. Since LuminAR has integrated camera, display, connectivity, and computation all bundled together into the form-factor of an ordinary Edison-screw-socket lightbulb, the users experience immersive interactivity in the lit-up area. Multiple LuminAR's overlapping the same surface area can auto-stitch themselves together to create supersized displays. And with the addition of robot-actuation in the lamp fixtures, an entire range of auto-orientation is an API away for the authors of smartbulb apps."

— ***Lecturer, MIT, August 2, 2011.***

"What struck me about LuminAR was that even without the robotics, it enabled computing to be installed in places not usually suitable - up out of the way in dusty, or hygienic environments where a laptop or touchscreen unit would be inappropriate."

— ***Lecturer, Monash University, August 2, 2011.***

"The device you created would have significant impact to the domain of augmented reality by providing a device that

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is easily installed and could be easily used in the home market. The LuminAR could be deployed with the movable base or installed in a standard six inch ceiling recessed lighting can above a desk, kitchen work area, bedroom, or anywhere providing augmented support for the user. The kitchen is a natural for news and recipes, and in the living room, office bedroom, televised information, videos, anything the user may want to view. The office would be another rich area for providing secondary display information like family pictures, news information, email prompts, scheduling, way-finding etc. You have a natural broad use product, and as the smaller laser projectors improve with time, the product will both evolve and improve."

– ***Research Manager, August 2, 2011.***

"I love the perspective-taking angle. LuminAR gives me the impression that the computer is changing perspective on how it "sees" me and responds to what I do. I think that gives me the impression that the machine is an empathic being. Maybe it is because I think of it as the little lamp that Pixar uses in their opening titles... Maybe it's the motion. Kinetic things remind us of animals. Awesome industrial design work!! I find laser projectors a bit hard on the eyes. I would love a LuminAR assistant on my desk!"

– ***Researcher, MIT, August 2, 2011.***

Based on the aggregate feedback received, as well as our own experience with the system, we have collected and outlined the key improvements that would make LuminAR ready for a rigorous user study down the road. We detail such improvements below, categorizing the suggestions into the areas of software, hardware/mechanical and interaction techniques.

Hardware/Mechanical Improvements

- Utilize better joint position sensing for LuminAR Arm. Current sensing relies on potentiometers that suffers from known accuracy, dead-zone and mechanical coupling issues
- Investigate and implement a low cost servo motor solution. Current off-the-shelf servos are excellent as a prototyping tool, but are too expensive as a real-world solution
- Utilize projection hardware dynamic view angle and auto-calibration capabilities. This should reduce computational load from the software process responsible for geometric scene registration running on the main LuminAR processor
- Add sensing for ambient light conditions, this will allow LuminAR to automatically compensate for changes in the ambient lighting conditions, contributing to the ongoing real-time calibration of the vision system, and resulting in improved interaction
- Add capacitive sensing to the arm and bulb, this will enable natural interaction by detecting when a user is actually

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touching a LuminAR device. This could also serve as an important safety mechanism

Software Improvements

- Improve computer vision algorithms; implementing a more robust detection scheme for hands and fingertip detection
- Implement full support for two hands multi-touch
- Develop a high-level Javascript APIs for kinematics control; for example, the API should support commands to define LuminAR device position for a specific user input or an application context.
- Develop a high level Javascript APIs for abstracting the computer vision coding requirements for interaction. Eliminate the need for an application developer to handle vision related coding in application code level

Interaction Techniques Improvements

- Improve overall interaction pipeline response time. This improvement may include processor hardware upgrade, but very likely refactoring the user interface events system
- Add gestures that seamlessly position the projected display on a desired surface; Support smooth transitions from a tabletop to a wall or a ceiling projection
- Design and implement better communication interfaces between LuminAR devices as an integral layer of the LuXor software stack; this will Improve the current naïve implementation used for the LuminAR Retail and LuminAR Spotlight integration in the APC applications and in the case of the LuminAR Augmented Desktop ScanApp.
- Add user interface feedback mechanisms for poor input conditions. This will improve the overall interaction when the system becomes less responsive
- Improve integration with other devices such as laptops, tablets and smart phones
- Implement animatronic feedback for user purposes. Create gestures and postures that can be integrated to application flow and provide cues to the user

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7 Conclusion and Future Work

This thesis focused on the design, engineering and interaction techniques for a compact and kinetic projected augmented reality interface. LuminAR challenges existing computer interfaces paradigms and form factor, offering a novel user experience that combines digital media interaction in a physical workspace.

LuminAR is inspired by more than 30 years of active research in the domains of interactive spaces, augmented reality, computer vision and personal robotics. We covered the key works in these domains in Chapter 2. The research approach for the work presented here integrated these domains with a design-driven development process. This approach motivated several prototype iterations we describe in chapter 3. The family of LuminAR devices that was developed in the course of this thesis work represents the result of this exploration.

The LuminAR Bulb, The LuminAR Lamp and Spotlight represent original hardware designs for compact and kinetic interactive projector-camera system. Product design and industrial design played a key role and informed the development of LuminAR prototypes. The result pushes the boundaries of embedding computation in everyday objects, making interfaces to digital information truly embedded in our environment. This is particularly relevant to the LuminAR Bulb that can simply screw in to a standard Edison socket, or to the LuminAR Lamp that can replace an existing Anglepoise lamp that is currently on your desk.

The design and implementation of the LuXor software framework represents our goal to create an embedded, web-based application framework and an operating environment for LuminAR. It required us to combine support for projected GUI; computer vision based natural interaction and robotic control in order to support the requirements of

We also demonstrated that LuminAR devices are practical for real-world scenarios. The applications we developed provided a glimpse into the future of projected reality interfaces in the personal desktop workspace and the retail domains. Even though our demos were domain specific, we can already see merit in exploring LuminAR applications for new domains such as education, medical applications, command centers and many more.

The interaction techniques we described in chapter 4 provide a glimpse into a future of kinetic interfaces and contribute directly to evolution of natural augmented reality interfaces. In this work we propose new interaction concepts enabled by LuminAR, namely Dynamic Multi-touch and Just-in-Time-and-Place Interactions. Our initial results and feedback, as captured in the demos of the applications we created, show the potential such interfaces have, but leave an open door for additional work that will explore further augmented reality a mainstream user interface modality. Specifically, kinematic interfaces enabled with kinetic I/O are still very much in the future and relatively

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unexplored. I believe that 'interface that can move' hold a great potential for the development of the field of human-computer interaction, but require further investigation and an abundance of design efforts. It is also important to conduct further formal evaluation of the interaction techniques we proposed.

To conclude this thesis and in addition to the list of immediate improvements we outlined in the previous chapter, I will provide a few future research directions that this research work may evolve into. It is hoped that the interaction design techniques as well as design principles we provided for kinetic projected augmented reality interfaces may enable such future user scenarios.

Object Augmentation and Manipulation

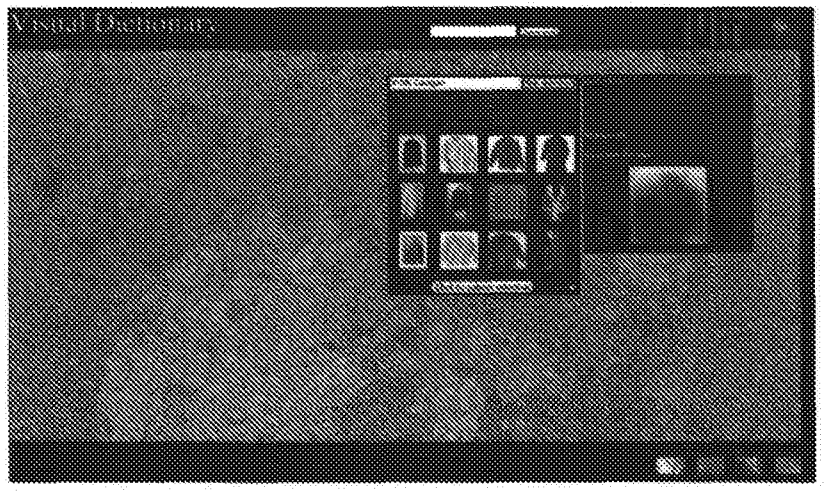
For projected augmented reality interfaces to become widely adopted, it is necessary to enable them with robust capabilities for object detection and tracking. Creating a framework for general-purpose object recognition is a hard problem that is still considered very much an open problem within the computer vision research communities. From an interaction point of view, such capabilities are important as they enable the design of user scenarios that include object augmentation.

Kinetic interfaces can potentially assist with solving aspects of this problem, utilizing the ability to dynamically position the sensors point-of-view to improve object detection and registration into an interactive scene. To achieve that, computer vision engines should be extended with software interfaces that can make perspective change requests in real-time to the motor control system. In doing so, and taking into account the already existing and known geometric model, the system may gain superior object recognition and tracking capabilities. Therefore, future systems could also benefit from the kinetic motion capabilities to dynamically augment objects with projected information.

From a hardware perspective, it is also possible to better integrate the sensor inputs in the bulb, namely combining depth sensor frames with standard camera frames to improve detection. In addition, automatic compensation for ambient lighting conditions should be added and used in real-time fashion while the system is moving from one location to another.

Finally, this approach should also take into account the advances made in the field of computer vision cloud-based datasets. Projects like Visual Dictionary [121], [122] propose new mechanisms to use billion of images to solve the general problem of recognizing all different classes of objects in the real world. This approach combined with an interface like LuminAR can prove a huge leap for projected augmented reality.

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MIT CSAIL Visual Dictionary by Antonio Torralba et al

Opportunistic Projection Surface Detection

Kinetic interfaces would be even more useful if they were enhanced with surface detection capabilities. Such future systems, during user interaction would be able to adjust to the targeted projected area. This approach has advantages for adapting the system to a changing physical environment. This can be beneficial for desk workspaces that are usually cluttered. We call this approach opportunistic location detection.

The algorithmic basis for implementing such features already exists. Known techniques like PTAM [123] can be used to efficiently identify surface candidates for projection. The real challenges lie in the interaction design required to create a valid user experience. Users fault tolerance for kinematic systems is very embryonic, and perhaps Hoffman's work on fluency can serve as a starting point [109].

Augmented Reality Interfaces Design Tools

If we follow the trajectory of Moore's law, it is clear that at some point projection and sensing hardware capabilities integrated with powerful microcontrollers will enable designers to build rich augmented reality interfaces.

However, current user interface design technologies have clear drawbacks when applied to the design of augmented reality interfaces. Current Digital Content Creation (DCCs) Tools and Integrated Development Environments (IDEs) are completely geared towards the development of display centric interfaces.

It is not hard to imagine how we can redesign such tools so they fit new interaction paradigms specific to augmented reality. I believe the gap is greater when it comes to the support of dynamic projected content and kinematic systems. Such tools should basically support the concept of just-in-time-and-place interfaces and augmented reality affordances. For example, development tools today are unable to model complex

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application flows that take into account projection location, size, object detection and tracking. The underlying computational models for such a systems has been explored before, for example Roy et al [124]. I also believe that this reality inhibits the mass adaptation of augmented reality as a mainstream user interface modality.

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Appendix

LuminAR Mechanical Specifications

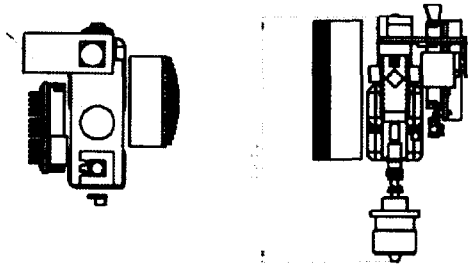
This appendix includes mechanical specifications for the various LuminAR systems developed in the course of this thesis work.

LuminAR Bulb Integration

Weight (w/out M2M Embedded computer)	460g
Diameter	150mm
Actual rotation range (degrees)	45°
Length	190mm

LuminAR Bulb Final

Weight	550g
Diameter	130mm
Actual rotation range (degrees)	270°
Length	170 mm



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LuminAR Spotlight BD

Overall length	1450mm
Belt & pulley mechanism length	1200mm
Pivot servo actual motion range (deg)	120°
Weight	3700g
Depth - to explain the mounting requirements	100 mm in the wall/ 18mm above +Bulb

LuminAR Optimus

Base diameter	304.8 mm (12 in)
Base rotation actual rotation (degrees)	90°
Hard stops	~90°, driven by cable length
Length of shoulder link	355.6mm (14in)
Length of elbow link	355.6mm (14in)
Interesting mechanical elements	All linkages are "doubled," servos directly attached to arms
Weight (estimated)	4000g
Elbow joint range (degrees)	100°
Shoulder joint range (degrees)	90°
Wrist joint range (degrees)	100° (actual range 65° because of weight + spring)

LuminAR Aluminum

Base diameter	254mm (10in)
Base rotation actual rotation (degrees)	360° / 90° with stops

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Hard stops	Cable management
Length of shoulder link	355.6mm
Length of elbow link	355.6mm
Interesting mechanical elements	Elbow spring is parallel to the base and attaches to the elbow with a long string, which goes through a pulley
Weight (estimated)	5000g
Elbow joint range (degrees)	~90°
Shoulder joint range (degrees)	~90°
Wrist joint range (degrees)	~70°

LuminAR Tipsy

Base circumference	241.3 mm (9.5 in)
Base rotation actual rotation (degrees)	90°
Hard stops	Cable management
Length of shoulder link	355.6mm
Length of elbow link	355.6mm
Interesting mechanical elements	Fork; servomotors are located on the base and connect trough hard linkages to the arms; Dynamixel servos
Weight (estimated)	4300 g (+ bulb)
Elbow joint range (degrees)	~90°
Shoulder joint range (degrees)	~90°
Wrist joint range (degrees)	~70°

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LuminAR SilverJack / BlackJack

Base circumference	241.3mm (9.5 in)
Base rotation actual rotation (degrees)	300°
Hard stops	Fork
Length of shoulder link	355.6 mm (14 in)
Length of elbow link	355.6 mm (14 in)
Interesting mechanical elements	The base is divided in two parts (lower steel for more mass); aesthetically designed fork and arms
Weight (estimated)	4300g (+ Bulb)
Elbow joint range (degrees)	90°
Shoulder joint range (deg)	93°
Wrist joint range (deg)	70

LuminAR Retail

Base circumference	241.3 mm (9.5 in)
Base rotation actual rotation (degrees)	300°
Hard stops	Lower arm / base cover
Length of shoulder link	355.6mm (14in)
Length of elbow link	355.6 mm (14 in)
Interesting mechanical elements	The base is embedded in the counter (86 mm); wrist has its own 4 bar linkage
Weight (estimated)	5000g
Elbow joint range	75°

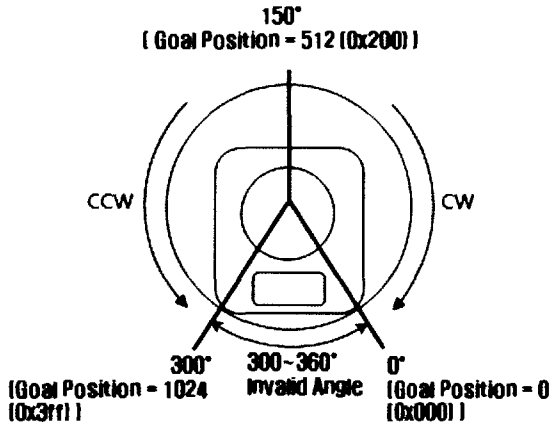
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(degrees)	
Shoulder joint range (degrees)	74°
Wrist joint range (degrees)	15°

LuminAR BlackJack / SilverJack S/W Limits (in encoder values)

Joint	Min	Max
Base	100	950
Shoulder	350	600
Elbow	370	635
Wrist	50	250

- To convert Dynamixel DX-117 encoder values to degrees:



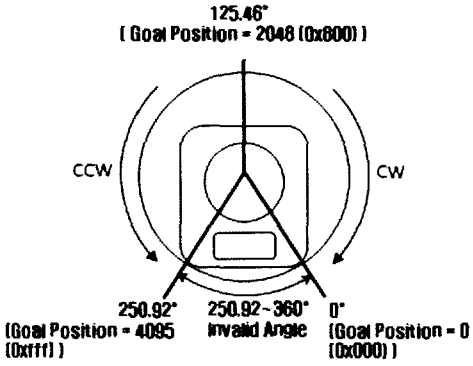
- See more at: http://support.robotis.com/en, Product Information / Dynamixel / DX Series / DX-117

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LuminAR Retail S/W Limits (in encoder values)

Joint	Min	Max
Base (DX-117)	100	950
Shoulder (EX-106+)	1651	2672
Elbow (EX-106+)	1306	2302
Wrist (DX-117)	400	600

- To convert Dynamixel DX-117 encoder values to degrees - see above
- To convert Dynamixel EX-106+ encoder values to degrees:

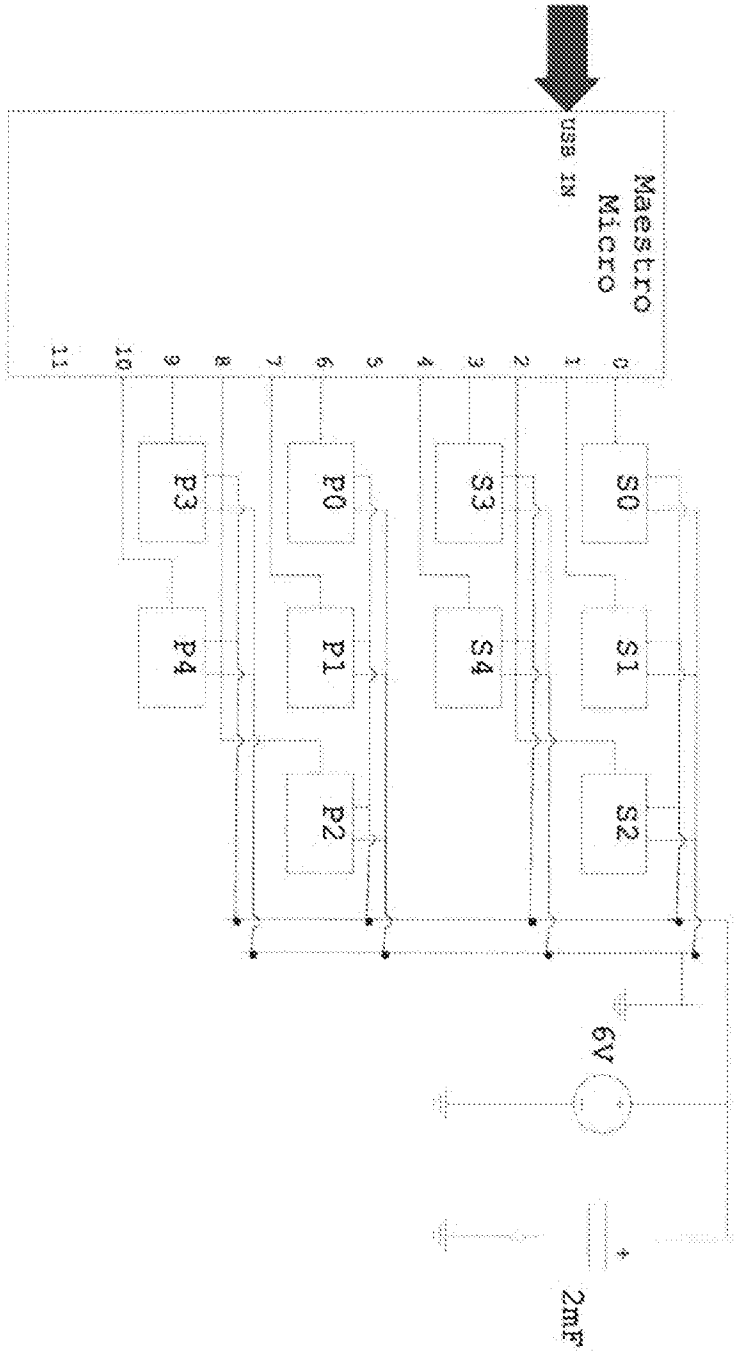


- See more at: http://support.robotis.com/en, Product Information / Dynamixel / EX Series / EX-106+

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LuminAR Arm R/C Servo Topology

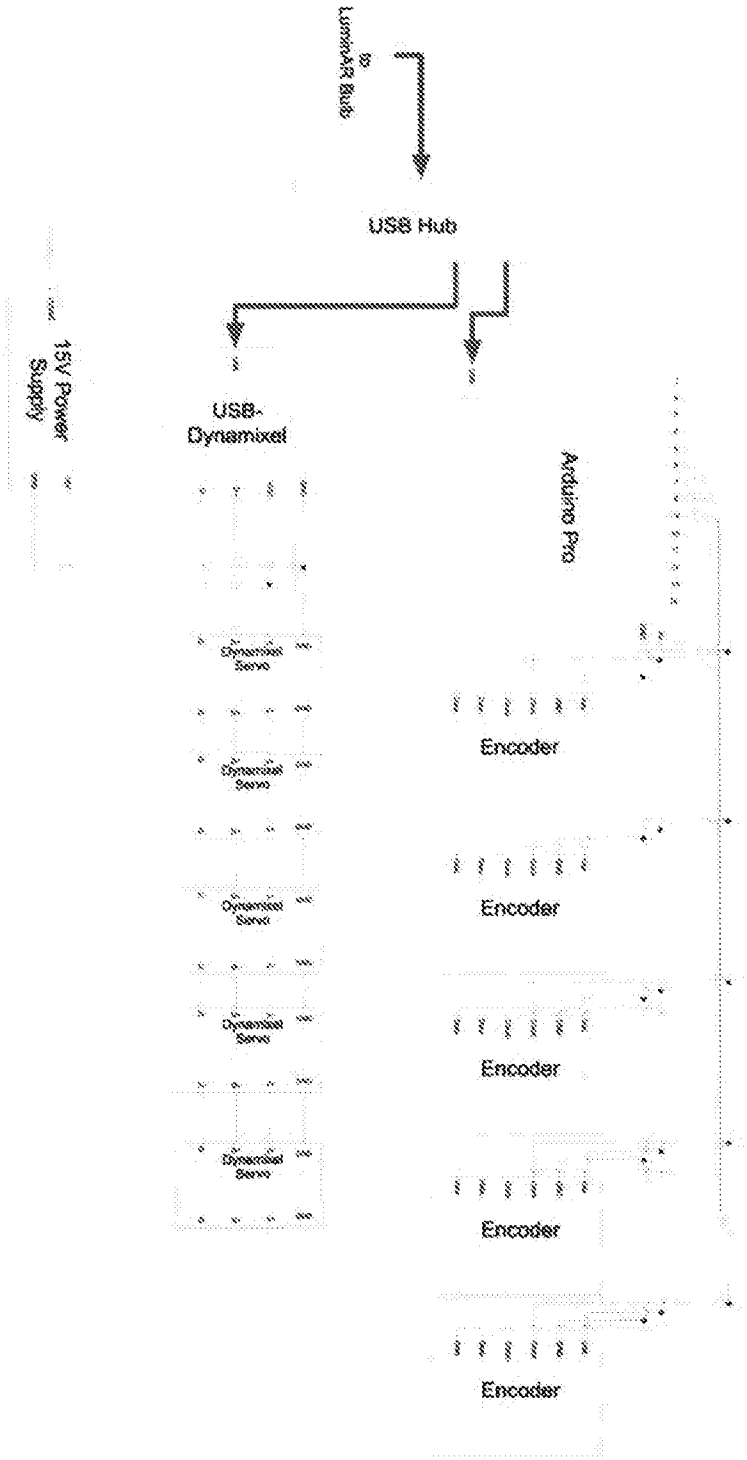
For LuminAR Optimus and LuminAR Aluminum



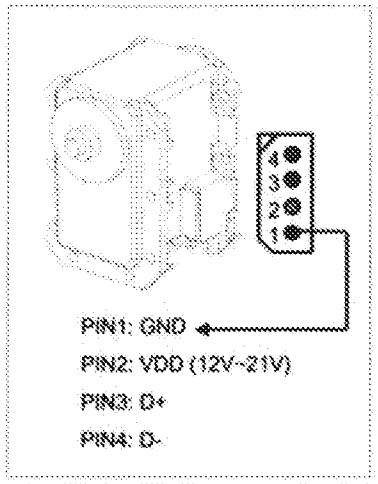
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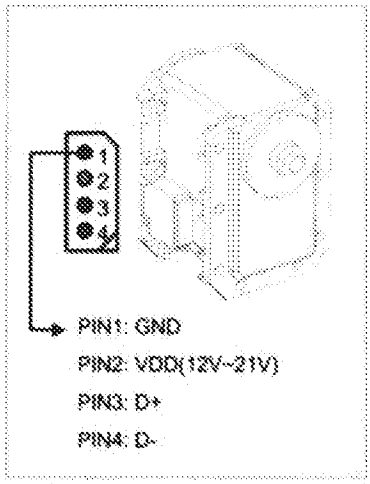
LuminAR Arm Dynamixel Servo Topology

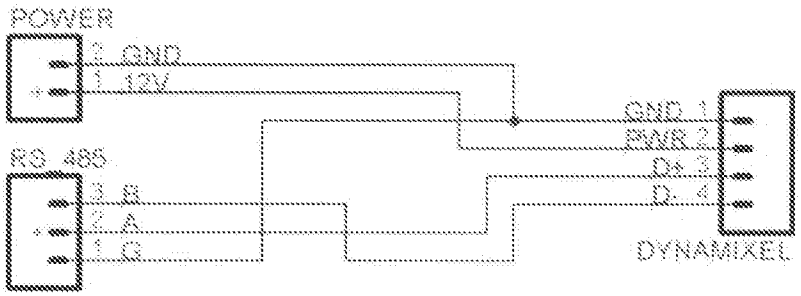
For LuminAR Tipsy, LuminAR SilverJack, LuminAR BlackJack, LuminAR Retail



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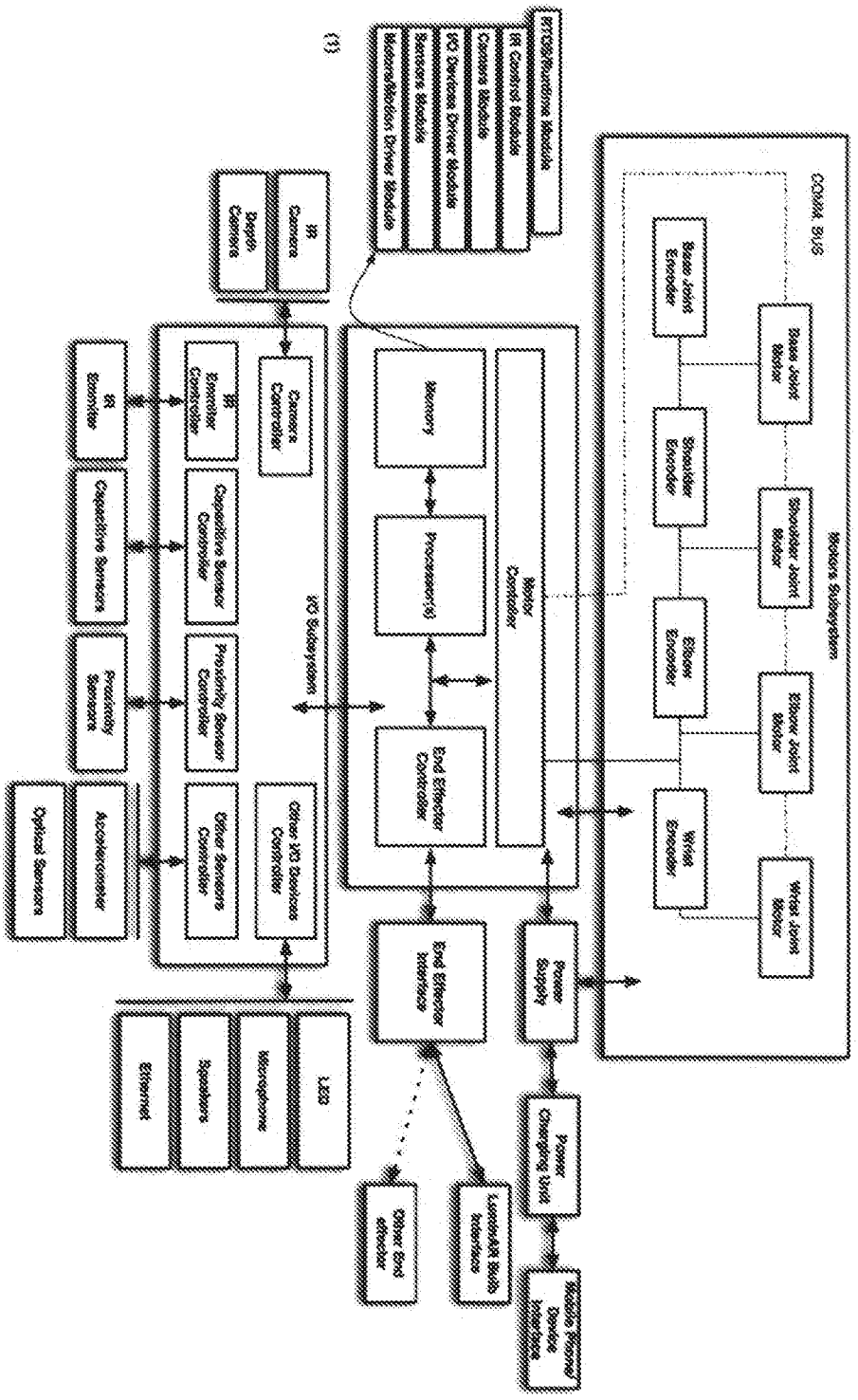






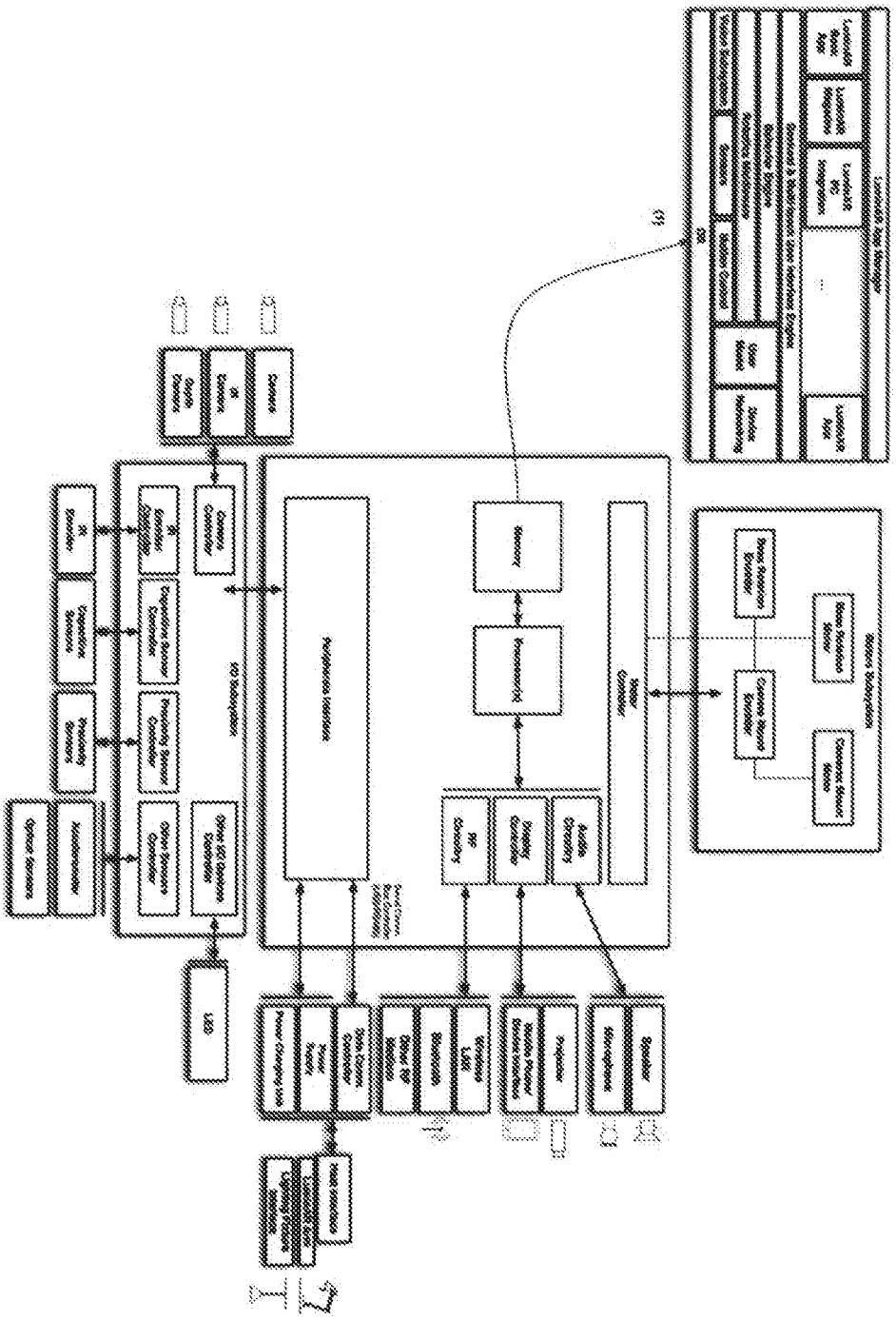
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LuminAR Arm High Level Block Diagram



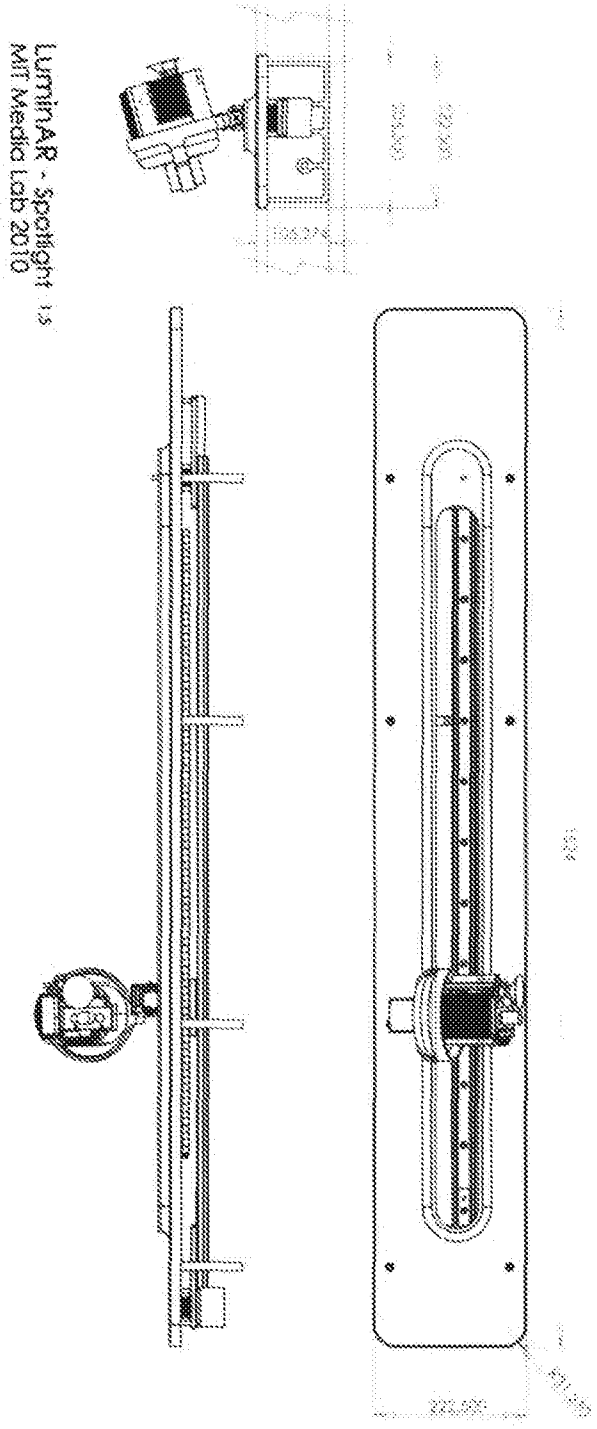
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LuminAR Bulb High Level Block Diagram



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LuminAR Spotlight Mechanical Overview

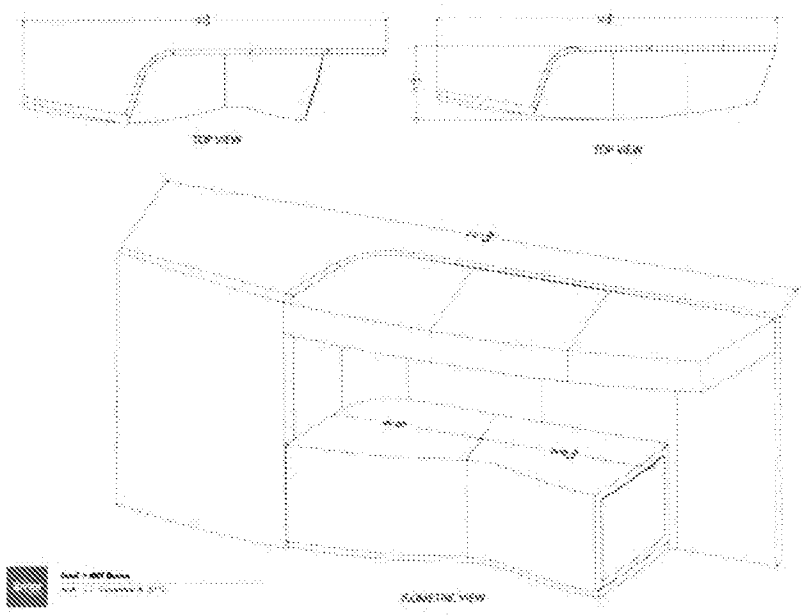


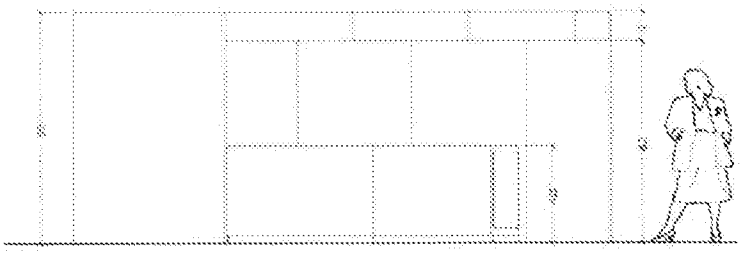
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Augmented Product Network Architecture

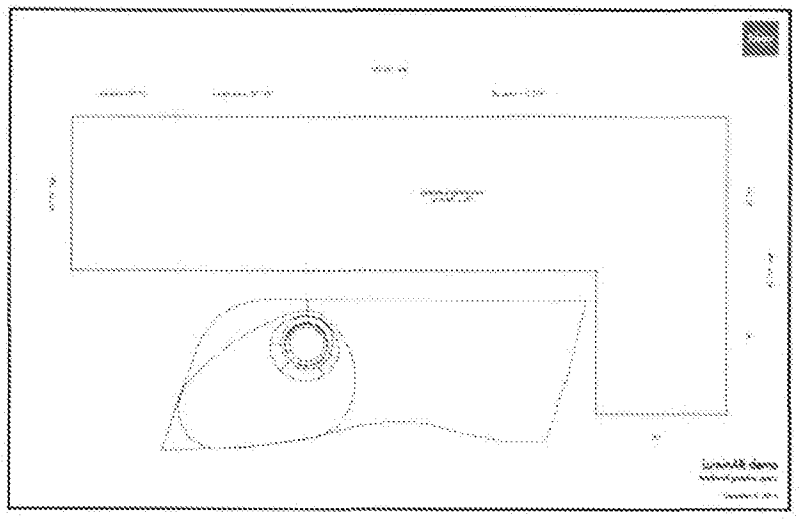
136

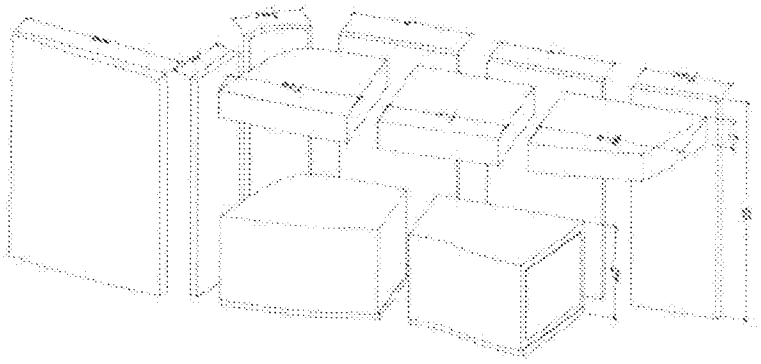
Augmented Product Counter Specification





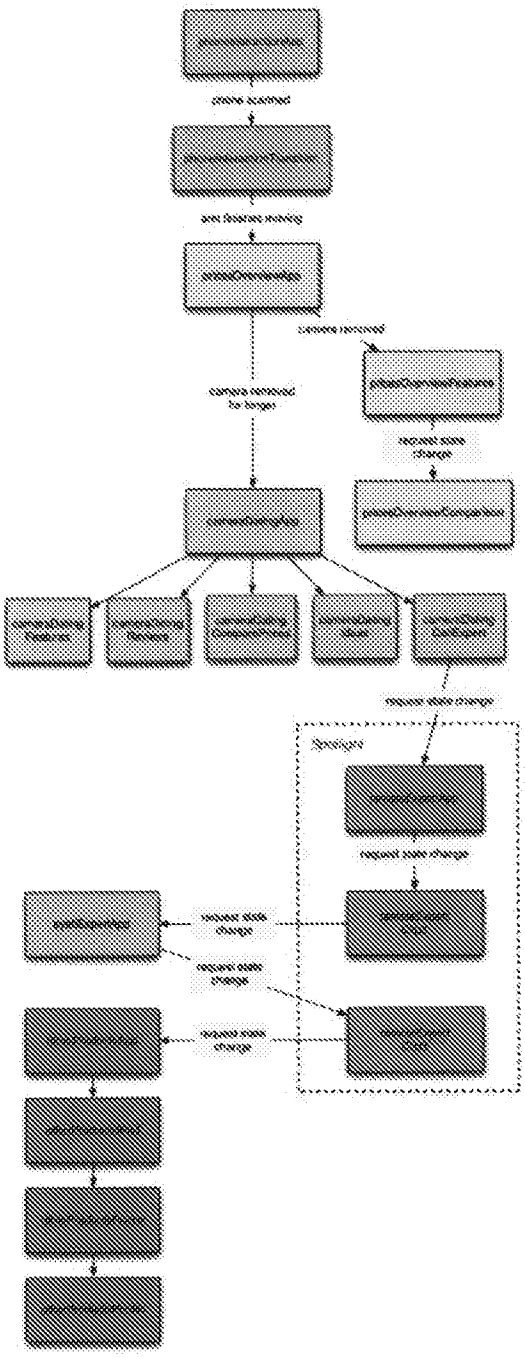
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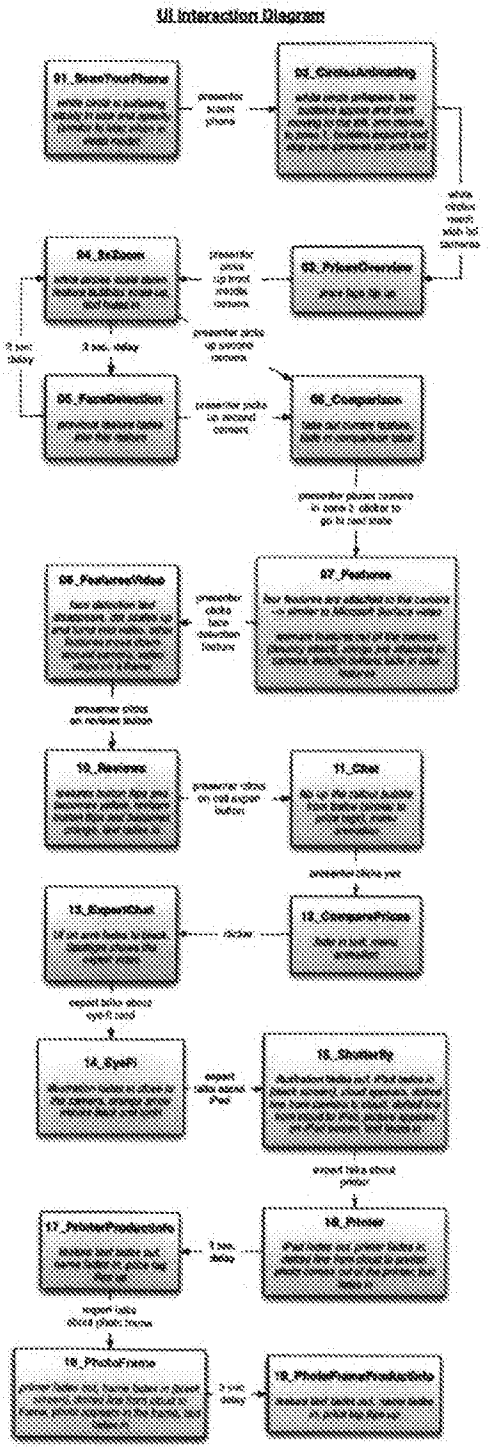
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Augmented Product Counter Demo Software – State Diagram



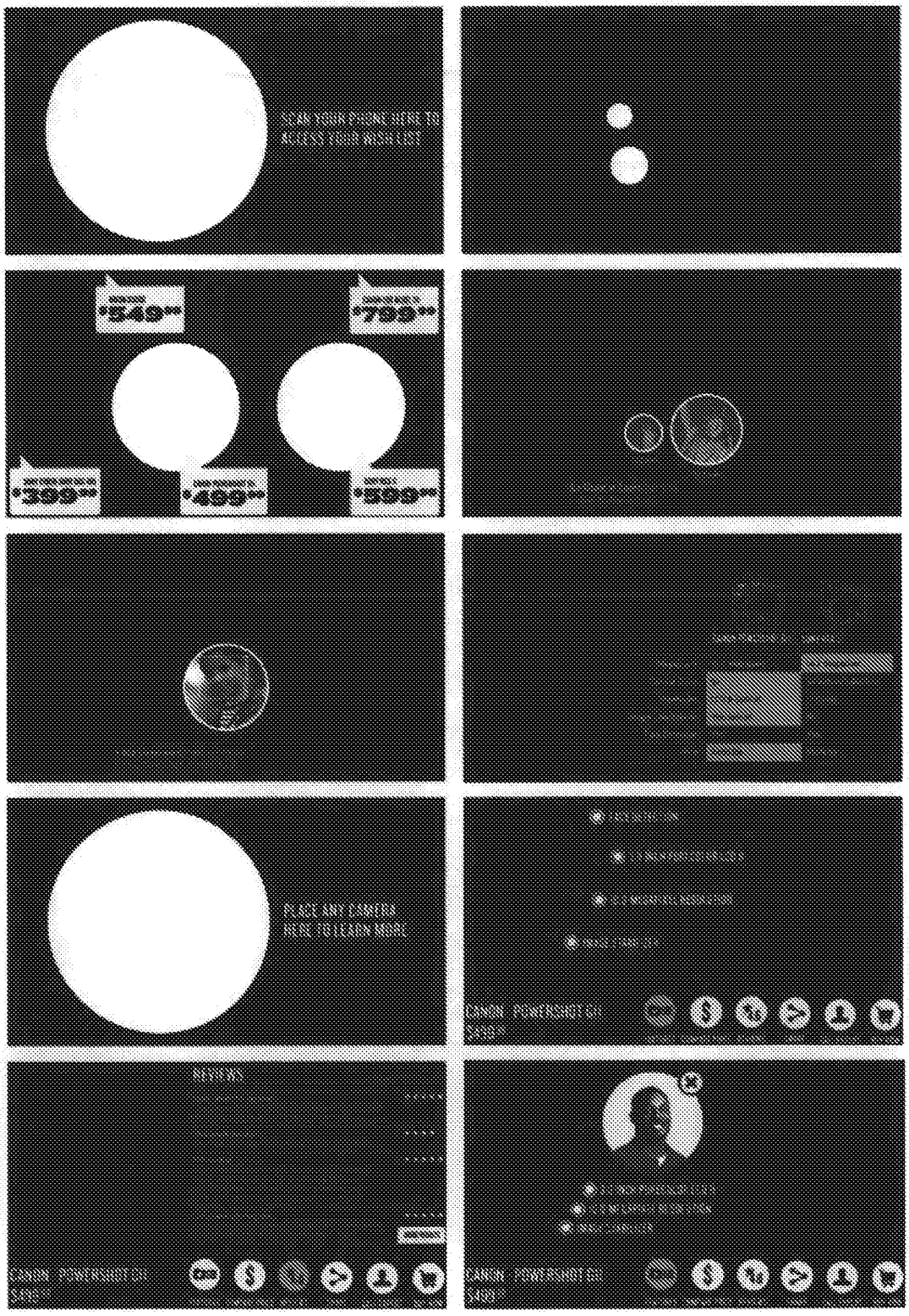
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Augmented Product Counter Demo Interaction – State Diagram

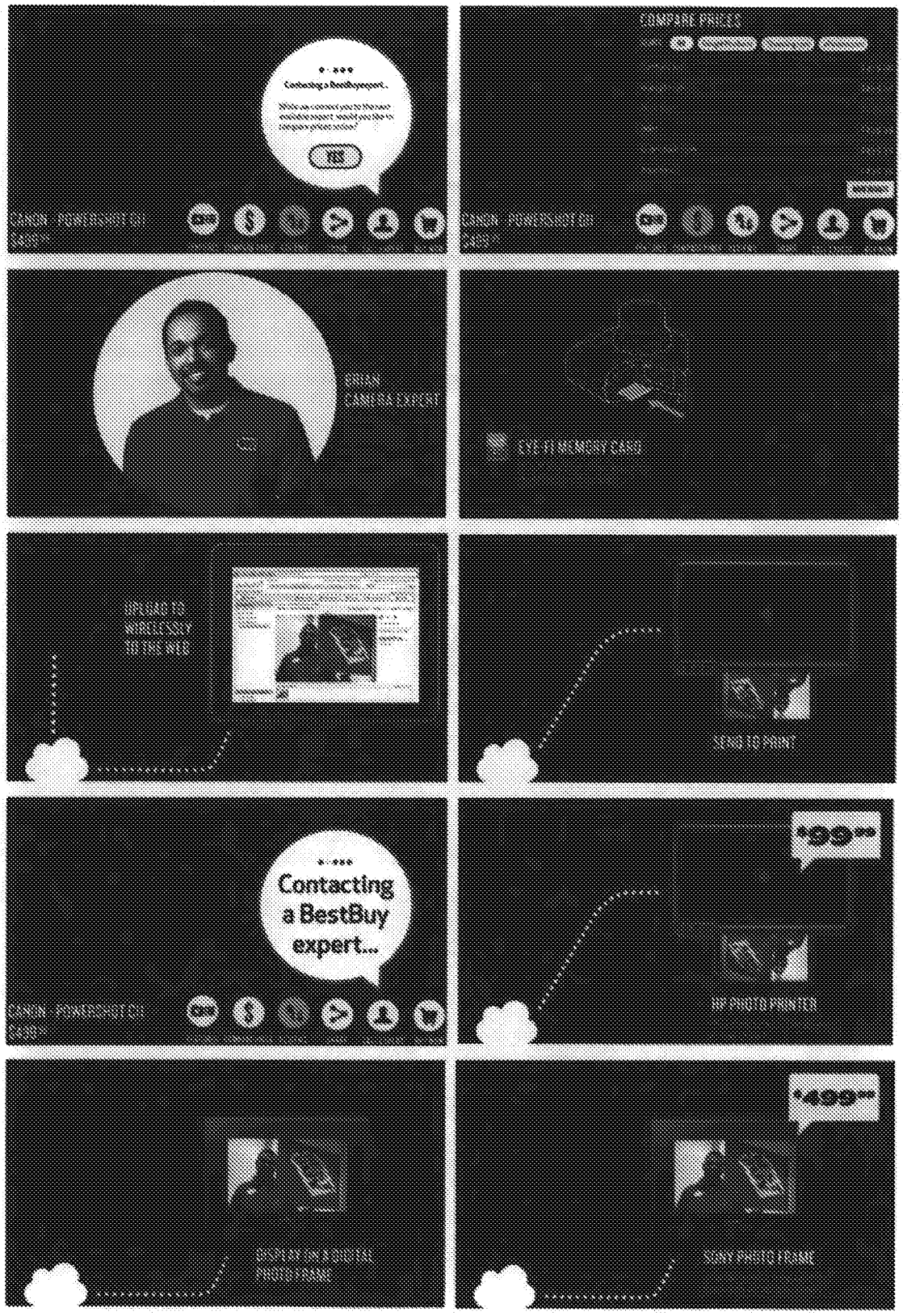


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Augmented Product Counter Demo – GUI



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Towards Optimal Worker Assistance: A Framework for Adaptive Selection and Presentation of Assembly Instructions

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Abstract— **Traditional systems for digital assistance in manual assembly, e.g. optical displays at the work place, are inherently suboptimal for providing efficient and ergonomically feasible worker guidance. The display of sequential instructions does not offer an increase in productivity beyond a certain degree. Little situational support and the resulting deterministic guidance lead to a reduced acceptance by the worker. A solution to this discrepancy is seen in an adaptive and cognitive system for worker guidance. Information from an adaptive process model and findings from experiments about human cognition are facilitated to provide the worker with assistive information, adapted to the situation and cognitive state of the worker.**

I. Introduction

Currently, a well-experienced work force on the shop floor is required to dynamically adapt to the current state of the process [1]. Consequently, complex capital products, e.g. machine tools, are manufactured in continuous manual assembly by teams of expert technicians. The reason for this originates from the failure to succeed in a detailed preliminary planning and usage of such to drive a guidance system because of the high dissimilarity and complexity of the goods [2]. Conventional, similar systems lack the ability of cognition, leading to serious deficiencies when acting in complex environments, especially in the context of human-machine-interaction [3]. Known systems for worker guidance operate on manually derived and statically compiled assembly plans [4][5]. Furthermore, literature shows mainly technical implementations of guidance systems based on Augmented Reality (AR). However, a successful application has to support the planning entity methodically sound. Only in this way, new technologies for efficient worker guidance will be usable [6].

In the following sections: A description of the flexible process model is given (Sec. II), the experimental setup for investigation of human cognitive processes is presented (Sec. III), methods and technologies for sensor-based monitoring of the manual workplace are described (Sec. IV), and an overview of the overall system architecture is given (Sec. V). Finally, an outlook is made.

II. Process Model for Manual Assembly

Representative digital systems for assistance in manual assembly situations in their current concepts are laid out suboptimally. These systems do not offer an efficient and at the same time ergonomical worker guidance [7]. The root cause thereof lies in the use of a single assembly sequence for planning the assembly system as well as for guidance of the worker. This assembly sequence, derived from precedence graph of a product, is only optimal and ultimately feasible under the view of long-term and hitherto known factors [8]. However, during runtime (i. e. assembly of a product) influences from the factory environment or variations in a-priori known conditions are not taken into account for the display of assembly instructions. Changes in sequence on complex products initiated by the worker cannot be reacted upon.

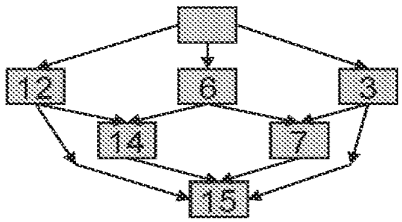


Fig. 1. Graph-based representation of the Assembly State Vector according to [9].

Several authors have modeled the entirety of possible assembly sequences for a single product in graph-based structures (e. g. Fig 1) [9][10][11][12]. These approaches have in common, that the main intention lies in reducing the combinatorial entirety of assembly sequences to the ones deemed as feasible. An assembly task is said to be geometrically feasible if there is a collision-free path to

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bring the two subassemblies into contact from a situation in which they are far apart. And an assembly task is said to be mechanically feasible if it is feasible to establish the attachments that act on the contacts between the two subassemblies that correspond to a state (not necessarily stable [11]. All operations of an assembly sequence have to fulfill both conditions strictly.

However, none of the existing graph-based representations allow for the selection of assembly tasks in real-time. This hinders the delivery of situationally adapted instruction to the worker. A key to solving these issue is seen in the application of adaptive and cognitive methodologies for the generation of assembly tasks. These require environmentally-dependant and situation-dependently triggered paths on state-based graphs. A mapping of the product's processing states and a dynamic determination of the otherwise sequential tasks is achieved by the graph-based structure shown in Figure II [13].

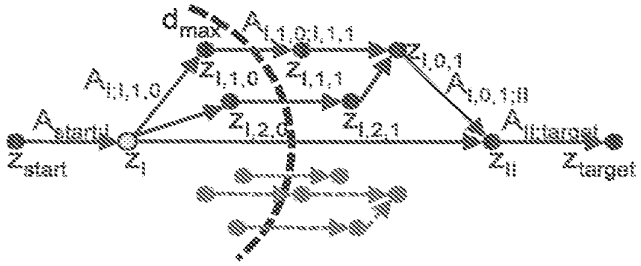


Fig. 2. Schematics of a state-based assembly graph [13].

Every product's set of instructions is defined by an st-graph. The product-specific graphs are deducted from construction and assembly-related information. In accordance with Figure II, the source vertex s represents the initial state of the product to be assembled (state z_{start}) and the sink vertex t represents the target state of the fully assembled product (state z_{target}). The edges of the graph (e. g. $A_{start,I}$) symbolize assembly task instructions. The execution of such by the worker will transfer the work piece in focus from one state to another (e. g. z_{start} to z_I). The path from the initial state z_{start} to the target state z_{target} leads across the respective major intermediate states z_{start} to $z_{target-1}$ (z_{II}). The minor intermediate states shown in Figure II ($z_{I,1,0}$, $z_{I,1,1}$, ...) are reachable via an increased degree of detail of the assembly task instructions. If a vertex has more than one outgoing edge $A_{i,j}$, then alternative assembly sequences or alternative parts can be disposed of.

The graph will not allow for cycles, under the presupposition that a disassembly of products to be built shall not be possible. This simplification entails, that the target state of the fully assembled product (state z_{target}) is reachable on a path from every state of the graph. Therefore, there are no states which would hinder a further assembly towards the target state. A future extension of the presented concept will account for disassembly tasks and is in the scope of the current research activities.

III. Investigation of Cognitive Processes during Manual Assembly

Manual assembly tasks involve the whole loop of cognitive functions from perception, attentional selection, working memory to action planning. For example, the type and amount of necessary parts for a workpiece has to be identified from the instruction and memorized for further action planning. Next, the relevant action, i.e. a reaching movement for an assembly part, has to be selected and executed.

In order to describe and investigate the relevant processing stages in more detail the information processing framework can be applied, which assumes that the sub-processes are passed through serially [14]. Adaptive assistance and facilitation of the assembly work requires the adequate support of each of these sub-processes, especially if new or highly complex tasks have to be executed.

A catalogue of neuro-cognitive methods for the experimental investigation of human performance and bottlenecks in complex assembly situations has been defined [15] and implemented partly in a working scenario [16] [17]. The methods range from behavioural measurements like error rates, completion and dwell times over motion and eye tracking to event-related brain potential measurements extracted from the EEG. For those measurements a Polhemus motion tracker system, an Eyelink remote eyetracker system as well as a video camera were integrated in a standard workbench. For instruction presentation, the workbench was equipped with a projector and a front-surface mirror enabling a projection which covers the whole working area (Fig. 3). This setup can present contact analog information, for example a highlighting of the relevant boxes where parts for the current assembly step are stored. Accordingly, the worker can be supported via context sensitive, adaptively generated instructions at the right time, location and with appropriate content. Additionally, a TFT monitor was integrated for the presentation of alternative or complimentary information. Two left and right foot pedals were applied for the user-controlled timing of relevant information presentation. This interface was chosen in order to not disturb the ongoing assembly process during the interaction, following the account of Wickens who described a model of distributed resources for the prediction of mental workload [18].

The described augmented workbench serves both as a research tool for the experimental investigation of cognitive processes in manual assembly, as well as a platform for the implementation of the assistive system, leading to a more efficient manual assembly performance. The value of the concept was tested within experiments, where different instruction modes and complexity of a manual assembly task were varied in order to manipulate respective processing resources. The impact of different instruction modes and task complexity on the assembly times and on the first goal-directed movement during an assembly task was investigated.

A. User Interface: Foot Pedals

An analysis of pedal presses, motion tracker data together with video records shows that the foot pedals can be used

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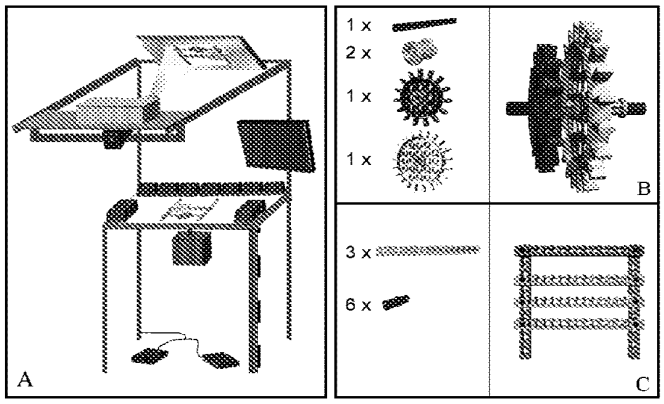


Fig. 3. Workbench and instructions [17]

as a user interface without the disturbance of the ongoing assembly process. Moreover, the interface conveys parallel working processes like e.g. quick checking of correct part assembly in previous substeps during the assembly procedure. It enables the observation of the exact point in time when new information is needed and of working strategies[17].

B. Task Complexity

The effect of task complexity as a manipulator of working performance was demonstrated in the dependent step times. Certain assembly step classes (i.e. gear fitting) lead to longer mean step times than others (i.e. gear assembly) with the same amount of parts, in accordance with difficulty ratings of the subjects [16]. Moreover, step times varied within one step class as a linear function of the amount of parts. Therefore, the observed mean assembly times with a certain step classes can be used together with the amount of parts for the prediction of completion times and mental workload during ongoing assembly [17].

C. Instruction Mode

Results demonstrate an advantage of contact analog instruction presentation. With complex tasks (i.e. gear fitting), the assembly times per part was about 10 seconds shorter with contact analog instruction mode in comparison to monitor presentations [16]. Motion tracker data deliver more detailed information on the subprocesses involved. So, also the onset latency of the first movement to a box was shorter with the contact analog mode (see Fig. 4). Moreover, peak velocity and peak acceleration were higher under this condition, possibly because participants were more confident concerning the relevant box position. Therefore, it seems that the highlighting of boxes enabled to select the relevant part position and to shift attention faster resulting in an overall decreased movement onset time and higher movement velocities [19]. The workplace augmentation methods used here will be improved and refined while adding sensors to the experimental setup, i.e. for box detection and hand tracking, as described in the next section.

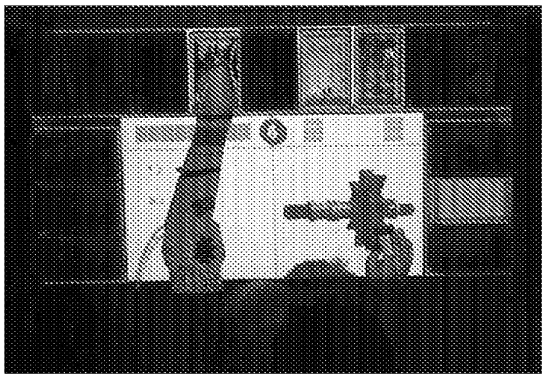


Fig. 4. Grasping movement to a highlighted box.

IV. Sensor-based Monitoring of Manual Workplace

To be able to monitor actions of a human worker, his workplace has to be equipped with sensors. For more details refer to [20]. The main components are explicit as well as implicit input modalities. Through explicit inputs it is possible to directly interact with the system, whereas implicit input is generated by monitoring the worker in the background. Here, vision-based sensors are used for tracking events in the background, with a global top-down view camera mounted above the workbench. This device has the overview over the entire work-area and makes it possible to watch the actions on the workbench and locate objects on the surface. These observations generate events that are used to adapt the assembly-plan. The following paragraphs describe how these events are produced.

A. Box detection

It is necessary to know what parts have been taken out of which box on the workbench. So, the boxes have to be located in a first step. This is done by analyzing the images taken from a top-down view camera.
The boxes used vary in color and size. To detect their positions in pixel coordinates, a color-based image segmentation is performed. To extract the relevant areas in the image-plain, thresholding filters in the HSV-color-space are used [21]. After converting the image into binary masks corresponding to each box color, a classification is done to determine whether an area is a box or not. The extracted regions are labeled, using connected-components analysis. These regions are further on called *blobs*. To identify blobs as boxes, their dimensions have to be nearly rectangular and cover a certain area in the image plain. Figure 5 shows a typical result of the box detection module on the workbench.
The center of gravity for each box is calculated and illustrated as a dot with the corresponding box-color.
This modality allows a free distribution of the storage boxes on the workbench and the worker can choose where he wants to place them. One could assume, that a frequently used part is stationed closer to the work-area, as a rather rarely required one.

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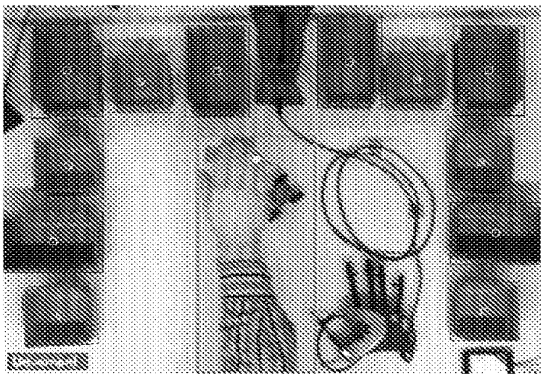


Fig. 5. Image-based workbench observation: box detection and motion recognition; picture from [20].

B. Hand detection

To decide which part has been taken out of which box, it is necessary to know, where the hand of the human worker is. For that, two operations are performed: restriction of search region in the image and detection of human skin.

1) Motion-Detector Module: Under the assumption that the worker's hands are moving while he is performing his task, only those areas are interesting, where the image has changed during an analysis-period. A motion-detector has been implemented for cropping regions with movement. If the number of changed pixels arises above a certain threshold, the corresponding regions are further analyzed. In Figure 5 the result of the motion-detector is also drawn in. The brown rectangle marks those areas, which have changed during the last analysis-period.

2) Modality skin color based hand-tracking: The next step for detecting the worker's hands is to find human skin in the image. Therefore, a skin color filter operation is applied to those regions in the image where movement was detected. The parameters of the filter operation are adjusted according to the skin color model of [22] in the rg-Chroma color space. After this operation, a binary image mask is created, similar to the box-masks from paragraph IV-A. Constraining the dimensions of these skin-colored areas (*hand-blobs*) to sizes of hands, more robust detection results can be achieved.
The actual position of the hand is approximated by the center of gravity of these hand-blobs. The combination of motion-detection and skin-color filtering improve the recognition results of the actual hand position. The final position is indicated as a cyan-colored dot in Figure 5. The small magenta-colored line points into the direction from which the hand motion started.

C. Sensor fusion

The previously shown processing steps are used to detect objects and generate raw data – e.g. position data for the worker's hands. For creating high-level events, these data have to be fused. The next paragraphs show how this is done.

1) Sensor fusion for hand-over-box-event: The presented methods for hand detection in section IV-B allow the system to get accurate information about the location of the worker's hand. The box-tracker provides the system with the positions of the boxes on the surface, presented in section IV-A. These raw data are used to generate a *hand-over-box-event*.
The distance between the centers of gravity of hand and box is calculated with the city block distance for 2D-points and stored as d_{box2hand}. The next step is to decide above which box the hand is hovering. The indicator telling if a *hand-over-box-event* has occurred follows the condition: if the distance between the box and the worker's hand is equal or less than 50 pixels, the value of the *hand-over-box-event* is set to `true`. Otherwise it is set to `false`.
The value 50 pixels results from the approximated diameter of a box in pixels. In Figure 6 the allocation of a box to the hand position is depicted. The accordant box is highlighted

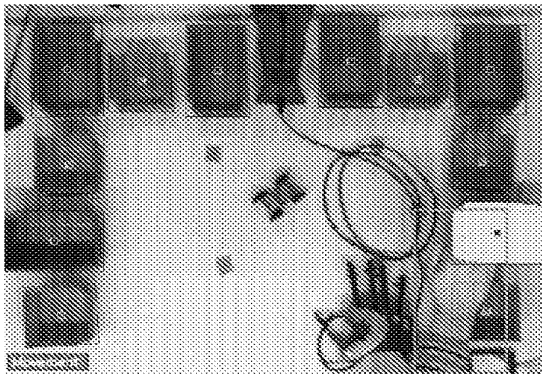


Fig. 6. Visualized position of the worker's hand, hovering the accordant box (highlighted in green); picture from [20].

with green color. At this point, it is possible to recognize over which box the worker's hand is hovering. This information is used to generate a grasp-event, described in the following paragraph.

2) Sensor fusion for grasp-event: To be able to detect, if the worker has grasped a part, it is necessary to define an additional parameter for this event. This is done with a time-trigger. Under the assumption that the worker will move his hands during the process mainly above the center of the workbench – the area with no boxes on it – one can conclude, that if he rests over a box, he will probably have taken parts out of it. Thus, the system triggers the *grasp-event*. The corresponding box location is gathered by the *hand-over-box-event*, described in section IV-C.1.

D. Allocation of box contents

The knowledge about which storage box contains which part has to be generated in an initial step. Here, the worker has to load the boxes manually with all available and needed parts for the assembly task. During this calibration phase, the system monitors that loading-process. The detection of the *lay-down-event* is the analog operation to the *grasping-event*, described in section IV-C.2. If a hand is over or in a box and the system is in calibration mode, then the event *lay-down-event* will be triggered. The deposed part is assigned

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to the box where the hand is hovering above. The generated associations are finally stored into a database to be available for the overall system.

V. System Architecture

In [23] a first draft of the architecture was presented, here, an overview of the up-to-date system architecture is given (Fig. 7). For implementation, the concepts and technologies introduced in [24] will be facilitated.

On one side, the process model defines tasks to be completed, and on the other side, the worker performs activities, aiming at task completion. The overall system intends to supply the worker with situation- and worker-adaptive assistive information, aiming at ergonomic worker integration and increase of efficiency, effectiveness and quality of the assembly process.

The system consists of 7 components: Personal Cognitive Assistant (PCA, at its core), Process Model, Generic Database of Human Cognition and Behaviour, Multi-modal Instruction Database, Input Layer and Output Layer. These components are described in the following.

1) Personal Cognitive Assistant (PCA): Core of the system is the Personal Cognitive Assistant. It receives feedback from and about the worker from the input layer and selects assistive information to be presented to the worker by the output layer. It provides the process model with situational feedback, as the desired step-size, and in return receives abstract up-to-date assembly paths. These are turned into actual assistive information by text, images, video and audio from the multi-modal instruction database. In order to adapt to the worker, a cognitive worker model is maintained, the workers assembly history is recorded, and worker preferences are derived and stored. To estimate the workers cognitive and physioligical state, his/her performance is compared with experimental data contained in the generic database of human cognition and behaviour. The PCA will be developed on base of the approaches described in [25], [26].

2) Process Model: The process model performs a mapping of the product state and dynamically determines the full feasible assembly tree and recommended assembly path for the desired step-size (Sec. II).

3) Generic Database of Human Cognition and Behaviour: The generic database of human cognition and behaviour contains results from experiments, as described in Section III: error rates, dwell and completion times, MTM, motion and eye tracking data.

4) Multi-modal Instruction Database: The multi-modal instruction database contains actual instructions in form of text, images and videos, which are used to enhance the abstract instructions from the process model.

5) Input Layer: The input layer generates events for explicit and implicit user input; Explicit input is generated from controls, operated by the worker (done/next, previous, postpone, refuse); Implicit input is based on surveillance of the worker as described in Section IV (handover, grasp, laydown).

6) Output Layer: The output layer receives assistive information from the PCA and performs hardware-specific adaptation and preparation for the actual presentation through the augmented workbench.

7) Augmented Workbench: The augmented workbench presents information through an overhead projector (Sec. III), it is equipped with controls for explicit worker feedback and sensors for implicit worker feedback.

VI. Conlusions and Outlook

A process model has been described, which is suitable to select assembly instruction adaptively, according to situation and desired step size. In experiments, knowledge about human cognitive processes and performance was gained, which will enter a database. A Personal Cognitive Assistant (PCA) receives explicit and implicit input events from a sensor layer, that monitors the human worker. The PCA keeps an assembly history and personal worker preferences, and maintains a cognitive model of the worker. Based on these and the generic knowledge about human cognitive processes, it is able to estimate the human's cognitive state and to request instructions with optimal level of detail, from the process model.

The system seems suitable to provide optimal assistive information and to realize system-ergonomic integration of the worker into a complete assembly system. Next are, the implementation of the complete system and its evaluation.

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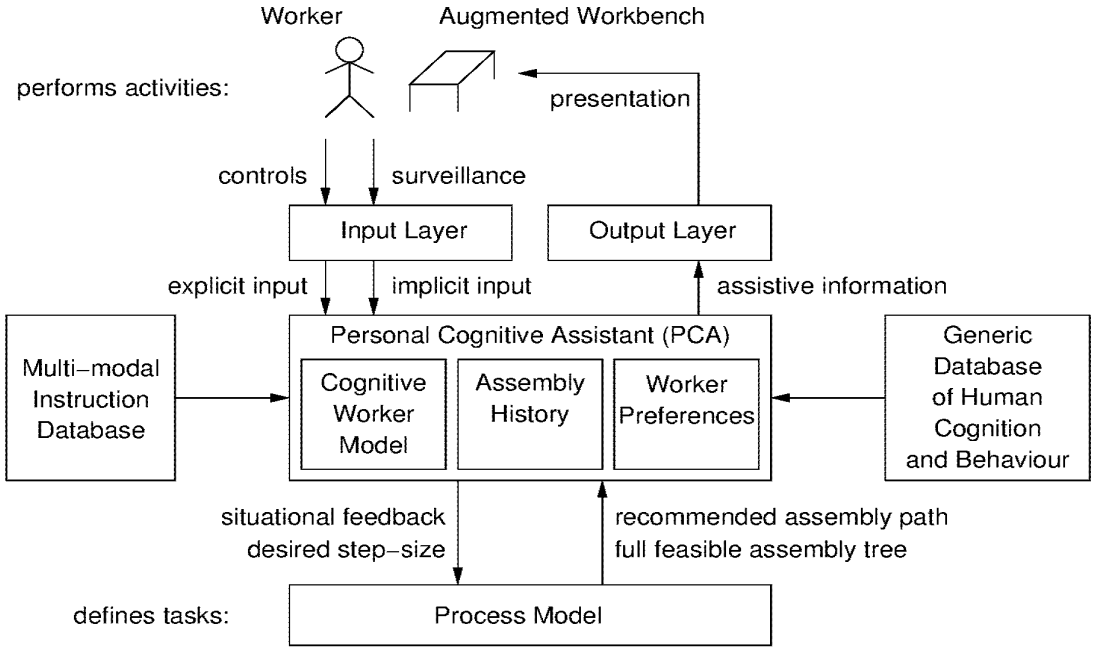


Fig. 7. System Architecture

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Improving Manual Manufacturing with a Computer Based Laser Projection System

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Assembly Guidance

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Improving Manual Manufacturing with a Computer Based Laser Projection System

Scott Blake
Assembly Guidance

Abstract

The application of computers to manufacturing has been largely in the area of total automation. (CNC, robotics, etc.). This paper describes a computer based laser projection system which is currently in use in several specialized aerospace applications. The system delivers accurate dimensional information directly onto large (meters), complex work surfaces for manual manufacturing tasks. Most manual manufacturing processes can be dramatically improved by delivering electronic dimensional information (CAD data) accompanied by electronically based multi media work instructions directly to the person performing the work. The results of applying this system will be lower costs, higher quality and improved time to market for products which are manually prototyped or manufactured.

Introduction

"World Class Manufacturing" has become a popular topic in discussing the problems of the American Economy. In a recent NAE report on Removing Barriers to World Class Manufacturing, Joseph Heim stated:

"The 'manufacturer of the future' confronts a daunting set of challenges: intense international competition in both domestic and foreign markets and incessant change in technology, product, process, customer requirements, and government regulation and constraint. The distinguishing characteristics of the globally competitive manufacturers will be the rapid, flexible, and innovative manner in which they respond to those dynamics, and the quality, competence and motivation of their work force."

In order to remain competitive, a development or manufacturing organization can no longer afford to operate as a group of independent elements. A "system view" must be adopted which takes advantage of technological and managerial innovations. The application of these innovations will improve the competitiveness of the complete organization."

" Heim, Joseph A., "Removing Barriers To World Class Manufacturing," National Academy of Engineering, October 1992

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This paper describes technological innovations which address local as well as system-wide issues in development and manufacturing organizations. The technological innovations are combined into a system which uses many types of media, computers, and laser projection to improve product quality, organizational response time, and overall cost.

The organizations that are affected by the application of the system are engineering, development, production and quality. The types of activities that are improved through the application of the system include training, process evolution, dimensioning, assembly, recordkeeping, production planning and tracking.

The improvements described here are based on the following concepts:

1. Some tasks are performed better by people than by machines

2. Some tasks are performed better by machines than by people

3. A system where people perform the work they do best, using machines which carry out functions machines do best, will yield optimal output.

While there is evidence of concept 3 in some applications, in general, manual and automated manufacturing are two separate worlds. The power of microprocessors has been applied in a large way to totally automated manufacturing tasks, engineering, finance, word processing, and many other areas, but it has been absent in direct use in the manual manufacturing world. This is due to a lack of effective methods of applying the power of microprocessors to manual manufacturing tasks.

Even with the widespread application of Computer Aided Design (CAD), the interface to manual manufacturing is still a physical drawing. Other instructions are still transmitted to workers in hardcopy (instruction books) which are generated on computers. Most of the tasks performed to carry out the instructions which have been generated on computers are performed with the same manual tooling techniques that were used before the advent of computers. Much of the documentation of the work is still carried out by people filling out forms where the data is manually entered into a computer.

These interfaces between computers and people are less than optimal. They require people to perform tasks in development and manufacturing which are likely to be of low quality, slow, and very expensive.

The reason that computer based machinery has not dominated development and manual manufacturing is that most of the tasks require visual, tactile and reasoning skills which are beyond the capability of machines. While the manufacturing tasks utilize the unique visual, tactile and reasoning skills of the workers, the workers are also required to perform many tasks which they perform poorly.

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System Purpose

The laser and computer based system described here will:

- Enhance the visual, tactile and reasoning skills of the workers
- Relieve the workers of most tasks which they perform poorly
- Electronically integrate the manual manufacturing organization with other functional organizations.

The result of applying the laser and computer based system will be that throughout the organization it will be much easier for people to get what they need, where they need it, when they need it.

A person performing a manual manufacturing operation is involved in direct and overhead tasks. The direct tasks are those where material processing is occurring. Everything else is overhead. Overhead includes training, finding and reading instructions, finding and setting up tooling to carry out those instructions, checking the work, and documenting the work. In many cases these overhead activities are cumbersome, and, as a result, are done poorly or not at all. The quality of the performance of the overhead tasks has implications upstream and downstream of the direct manufacturing tasks.

Figure 1 lists manufacturing activities and compares the capabilities of an automated system with an unaided manual manufacturing system. It also rates the capabilities of manual manufacturing combined with the laser and computer based system described here.

System Description

The combining of:

- Microcomputers that provide operator interface as well as sending and receiving data
- A vector scanning laser projector
- A registration system which can calibrate the relationship between the laser projector and the work surface yields a system which can enhance manual manufacturing in improving quality, speed and cost reduction. This system replaces many components and activities of a traditional manufacturing system. The components within a manual manufacturing system that are most significantly affected are:

- Providing instruction and training to workers
- Delivering production data to workers
- Dimensioning of work
- Recordkeeping
- Process evolution

Providing Instruction and Training to Workers

The best place to train is the actual place where work will occur. The best time for training is as close as possible to the time when work will occur. It is difficult for traditional training methods to meet these requirements.

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A Comparison of Automated, Manual and Computer/Laser Assisted Manual Manufacturing Activities

	Total Automation	Manual Only	Manual Manufacturing w/ Proposed Laser and Computer Based System
Obtaining Proper Production Data	Excellent	Slow & Error Prone	Excellent
Dimensioning	Complex	Slow & Error Prone	Simple & Accurate
Handling Diverse Material	Difficult	Excellent	Excellent
Recordkeeping	Excellent	Fair	Excellent
Learning Curve for New Process	Slow & Expensive	Fair	Optimal
Process Evolution	Always requires People	Good	Optimal
Inspection	Difficult	Difficult	Good

Figure 1

When training is performed in a location and time removed from a manufacturing activity, the interruption of attention reduces the effectiveness of that training. The interactive multi media functions on the proposed system allow the assembler to request moving color pictures with sound at any time during production. This media can be adjusted to provide the maximum value in providing the information required for any manufacturing process. This media can take any appropriate form: laser dimensions, video, audio, CAD, still photos, etc.

Delivering Production Data to Workers

Many manufacturing problems are associated with the production, maintenance and storage of hardcopy of production data. The time required to implement changes in instruction manuals or blueprints which are used on the shop floor is significant and often not done correctly. Electronic data is much easier to control and update. A single responsible system manager can deliver clear data to many people for many applications in a fraction of the time required to handle hardcopy.

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Dimensioning of Work

One area of manufacturing which consumes large amounts of time and tooling involves dimensioning. Dimensions for manufacturing are generated on a Computer Aided Design (CAD) system. These dimensions are stored electronically and plotted out for assemblers to use. When an assembler uses one of these plots (a blueprint) they must go through many complicated steps. The actual sequence of accomplishing the overhead task of dimensioning from a blueprint requires:

1. Deciphering the blueprint to determine which step is performed next

2. Obtaining a tool which can be used to create the dimension shown on the blueprint

3. Memorizing the dimension and its references from the blueprint

4. Reorienting from the blueprint's scaled down dimensions to the full size work area

5. Using the tool to reproduce the memorized dimension deciphered from the blueprint

6. Verifying that all of the previous steps have been done correctly

7. Performing the action which references the place where the actual manufacturing will occur (mark, align, scribe, etc)

The laser projection system eliminates these steps by projecting dimensions at the touch of a button. The elimination of these steps (which present many opportunities for error) speeds the process by having the assembler perform only the tasks that the assembler performs best.

Recordkeeping

The gathering, storing and sorting of data is easily accomplished with computers. The system described here utilizes simple button pushes accompanying each step in a manufacturing process. The pushing of these buttons triggers the storage of sequenced, timed events which are stored for future use in Industrial Engineering Studies, production verification and process analysis.

Process Evolution

By reviewing detailed data on each step in a manufacturing process it is possible to isolate techniques that contribute to high or low quality. By identifying and correcting or communicating specific activities, the best manufacturing process will evolve in a clear and positive way. This ability to measure and easily implement process changes is a fundamental component of a Total Quality Management (TQM) program.*

* Blake, Scott, "Laser/Computer-Based Tooling for Composites: Impact on TQM Objectives," SME #EM90-180, 1990

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Economic Justification

An Example of Cost Savings Resulting From the Elimination of Ply Placement Templates In Hand Laid Composites Manufacture In Aerospace

In the Aerospace Industry, the production of many parts made of advanced composites is performed using a process known as hand layup. The assembler places pre-cut plies of material (prepregs of carbon, kevlar, glass and honeycomb) onto a mandril to build up a laminate. Accurate positioning of these plies is required to assure that intended part performance characteristics are achieved.

A comparison is made between traditional template tooling and a system using vector scanned laser light. Two examples are used to provide projected costs, where cost models are available. The assumptions for the examples are:

- Part #1: a medium sized, complex curved tool which is 4' by 6' with 40 pieces in the layup kit (plies and honeycomb)
- Part #2: a large sized, complex curved tool which is 5' by 12' with 80 pieces in the layup kit (plies and honeycomb)
- Each ply has 6 scribe marks (eyebrows in each template) per ply
- Both tools require 2 physical templates, one for plies before honeycomb, and one for plies laid up over honeycomb
- Templates are stored on end in a special rack on wheels, which is located with easy access to the tool
- A total labor rate of $52.65/hr. based on the following assumptions:
  - labor rate: $15/hr.*
  - benefits: 30%
  - correction factor: accounting for fatigue, delays, and personal time: .35.**
- Overhead Rate: 2.00
- Template Handling Time: $H=0.000107A^{0.7701}$

Where: H=Hours per template, A=Area in inches ***

Part #1 Template Handling Cost: $291/part

Part #1 Laser System Operation: $42/part

Savings: 85%

Part #2 Template Handling Cost: $1,242/part

Part #2 Laser System Operation: $86/part

Savings: 93%

* Employment Hours and Earnings, United States 1909-1984, Volume II, Bulletin 1312-12, U.S. Department of Labor, Bureau of Labor Statistics, March 1985, p324.

** Ostwald, Philip, Cost Estimating, Prentice Hall, Inc., New Jersey, 1984, p47.

*** Northrop Corporation, "Advanced Composite Cost Estimating Manual," AFFDL-TR-76-87

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Cost Comparison for Templates vs Laser System for Dimensioning Hand Laid Composites*

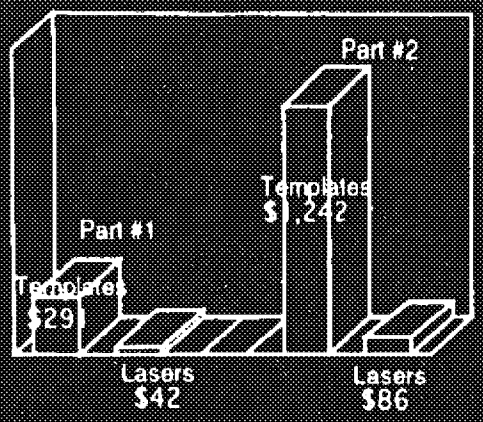


Figure 2

Fabrication represents 72% of the cost in finished composite parts.** The savings of 70% to 90% at key production stages will significantly reduce the finished part cost.

Other Benefits

The basis of all improvements related to this system is the value of rapidly available, appropriate information. Each form this information takes in a more rapidly available, appropriate context is a benefit.

The forms for this improved information flow include:

- work order scheduling
- work order tracking
- process information (training)
- dimensioning for production
- dimensioning for inspection
- Engineering Change Orders (ECOs)

The result of this improved information flow is a system-wide increase in speed, an improvement in quality, and a reduction in overall cost. These improvements are generic goals for any manufacturing organization.

Risk reduction is achieved in prototype or early stage production because hardware tooling is expensive to produce or modify. The laser tooling, handling dimensions and patterns electronically rather than physically, is created quickly and is easily modified.*

Current Applications

Since 1989 a system which combines computers with a laser projection system has been in use in the Aerospace Industry. This product is called LASERGUIDE and it is an electronic dimensioning system. It is used to replace templates which are required to define the boundaries of plies of composite material and honeycomb core which are being built up by hand to create a laminate.

* Blake, Scott, "Replacing Composite Hand Layup Templates with a Simple Projection System," SAMPE Symposium and Exposition Series, May 1989

** "Fabrication 70 percent of cost for advanced composites," Advanced Composites, pg 12, July/August 1988

* Hyatt, Donald G., "Design Producibility at MDHC," Composites in Manufacturing 8, Conference Reading, SME, January 9, 1989

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LASERGUIDE is in use building composite internal primary aircraft structures, airfoils, and skins.

The experience in these applications has included a significant reduction in production time, compatibility with CAD systems, success with "paperless" documentation, a rapid application of engineering changes, a highly favorable reception by assemblers and an improvement in quality of parts produced.

A pilot program integrating graphic work instructions with LASERGUIDE was initiated in the Spring of 1993. This system employed all of the functions described in this paper. The total system is expected to enter widespread application in early 1994 in the construction of hand laid composite aircraft parts.

Other Applications

The initial applications for the type of system described here are in the aerospace industry. The applications involving advanced composites require frequent engineering changes on expensive parts produced in small quantities. The system can be applied in any application which requires information delivery and tracking in manual manufacturing. The laser can project onto large complex curved surfaces. Other audio and visual media can easily be transmitted.

Examples of other applications include welding, any process requiring lofting techniques, rapid prototyping with wood, metal, cloth or plastic, wiring, plumbing, painting and general assembly.

Conclusion

A system combining laser projected dimensioning with multi-media graphic work instructions can improve many indirect and direct manufacturing processes. The system is based on currently available technologies which can easily be cost justified for many applications. These technologies allow production workers to get the information they need, where they need it, when they need it so they can produce parts of the highest quality in the shortest time at the lowest cost. Combining computers and other machines for tasks that perform better than people, with people performing processes that are not easily performed by machines, will yield optimal results. Examples of this type of system are in use producing parts with the improvements listed here. Secondary benefits are gained in management and other manufacturing overhead activities in areas of work order scheduling and tracking. Process data for evaluation is easily compiled and process improvements are easily implemented.

Achievement of the goals listed here (quality improvement, shorter time to market and lower unit cost) will be necessary to compete in the global manufacturing marketplace. The system described here will provide a major step forward for leaders in this arena.

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Laser Guides Manual Assembly

Arthur Browne

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The capabilities of automated production equipment continue to increase while the costs of the equipment fall. Software based electronic control of mechanical systems has increased the functions available and simplified the task of producing the required sequence of operations. A processing unit can be programmed to switch from one pattern of operations to another before each workpiece and thereby allow "batch of one" operation. The pattern and the parameters for each operation can be selected either by a supervisory computer or following the reading of a code, perhaps a barcode label, on the carrier of the workpiece. Sensory systems, such as vision systems, can be used to determine the positions of the workpiece and the components so that accurate jigging is not required. Also sensory systems can be used to determine that a task has been completed correctly and to inspect the quality of the workpiece before and after the operation.

We can now contemplate the automation of production processes that a few years ago defied a solution at a viable cost. This improvement will continue but there are, and will remain, processes that cannot be automated at an acceptable price or even at almost any price. In these the human operator will retain his/her place. The human operator has many advantages. These include flexibility, adaptability, dexterity and an ability to reason which is beyond that of computer systems; even with the addition of artificial intelligence and expert system software. He/she can easily combine the process with the inspection of the initial parts and the resulting workpiece, often at a speed exceeding that of automated equipment. If faults are detected in the parts to be processed, e.g. bent leads on an electronic component, these can be corrected or the part rejected.

Why is there a desire to automate processes? Direct labour cost is not usually a significant reason and, when automation is difficult, its cost can be a negative factor. Probably the most common incentive is to eliminate the variability in the performance of the operator, which varies on daily and weekly cycles, health, the weather and distractions. The need to automate is reduced if the consistency of performance is improved and the frequency of errors is reduced. Typical errors are placing a component into the wrong position in a circuit board or the wrong screw into a hole. Frequently this is due to the way in which the components and the list of process instructions are presented. If the process were to be automated much attention would have to be paid to these two aspects. Feeders would be provided for the components, so that they were presented in precise positions, and a computer program would present the instructions one at a time. Why not provide better control of the components and instructions for the operator?

Errors are expensive, often very expensive. Even when the error is spotted by the operator immediately after making the error, correcting it interrupts the rhythm of the operator and adds time to the operation. In some cases this time may be many times the assembly time, for example the removal of an integrated circuit soldered to a circuit board, and may result in the scrapping of some of the components. Correction costs increase when the error is not spotted and the product moves through other production stages. Eventually it may be impossible to rectify the fault so that significant value has been added to a scrap item. Further, if there are automated stages later in the production line, the error may result in damage to the automated equipment. The conventional solution is to place inspectors at appropriate points along the line. They may miss errors if they have many aspects to check. Also inspectors add cost to a product but

Thanks to MEL of Crawley, for whom the cableform system was developed, for permission to publish and Derek Miles of MEL for his assistance in developing the system.

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do not produce anything themselves. Thus the financial incentive for automation often arises from low quality and its effect upon marketing.

In one area improved control of component and instruction presentation has been employed with very good results, namely the assembly of leaded components into printed circuit boards. Components are placed in bins on a rack or carousel, each bin having an indicator lamp. The circuit board is fixed in a defined position on the worksurface. Above the board there is a lamp house from which a beam of light is projected onto the board. This beam can be deflected by a pair of mirrors in the lamp house to illuminate any point on the board. A computer program, designed for the assembly of the board, controls the deflection of the beam and the indicators on the component bins. In this way the component to be taken and its position on the board are indicated. It is also possible to display on a monitor additional information and instructions, for example, a description of the component.

A similar but more advanced technique has been applied, by the author, to the assembly of cableforms. Cableform assembly is amenable to automation when a single wire type, or a very limited number of types, is used with a limited number of termination types. Even so the binding or sleeving of the cableform can present serious problems unless special binding and sleeving devices are used. Also special layout boards with guide pins are required and usually total automation is not economic unless the cableforms are made in large batches.

A typical procedure for the manual assembly of a cableform starts with a board carrying a mechanical diagram of the cableform into which pins have been driven to define the shape of the cableform. The cable drums are mounted on a rack and terminations and other components are in bins. Assembly instructions are on sheets with each line giving the instructions for a wire — type, colour, end positions, route, identity numbering of the ends, terminations, etc. Following the instructions, a wire is selected and laid. Terminations may be fitted before, during or after the laying of a wire but usually, when multiterminal devices are used, these are fitted after several wires have been laid.

The risk of error in such a procedure is high. The information may be typed or handwritten and can be misread. All the information for one wire cannot be retained in one reading and the data must be referred to several times. In this is the risk of returning to the wrong line on the data sheet. Wire positions and identities are numerical and the mind is prone to change or interchange digits especially when many different numbers are used during the assembly. Consequently it is not unusual for a wire to be omitted, the wrong wire to be used, the wrong path to be followed or the wrong identities to be fitted, to name but a few of the common faults. Equipment exists for the checking of cableforms by continuity tests but often it is not economic to set up such equipment for the testing of small batches. In most cases the fault is not detected until the cableform is being installed and, at that time, rectification will be expensive.

A solution to this problem of the introduction of errors is to improve the method by which data are presented to the operator; to present those data which are required for each stage of the process and only those data. Also to present the data in a clear, unambiguous and meaningful way. Besides reducing errors this technique can reduce the time taken for each stage of the process. Although this technique has been applied to cableform assembly it is applicable to other processes.

Information is supplied to the operator in two ways; by a display on a monitor and by a laser beam projected onto the work surface where the cableform is assembled. A monochrome monitor could be used but the use of colour improves the assimilation of the data. The laser beam is deflected by a pair of mirrors in a unit, containing the laser, mounted above the work surface. The spot can be moved to any point on the surface with about 4,000 steps across the width of the board and 2,000 across the height. The laser is a helium-neon gas laser with a power less than one milliwatt. Compared with the incandescent lamp used in the circuit board assembly system, the laser has the advantage of an intense, collimated, narrow beam. This allows small mirrors to be used and thereby faster deflection and settling rates. This is important in producing displays with a low flicker. In principle, galvanometer mounts are used for the mirrors with positional feedback to the driving amplifiers. Each required position is fed from the computer to the amplifiers as two 12-bit numbers.

The list of operations is divided into steps, usually for the processing of a single wire. The data for each step are written into a "window" relating to a display on the monitor, with additional information for the deflection of the laser beam. The series of windows form the data file for the assembly of a cableform. A special program is available to aid the generation of this file. Typically a window display on the monitor will show the wire type (size, insulation, colour), the positions of the wire ends (numbers corresponding to those on the layout sheet on the work surface), identity numbers for the ends and termination details if the ends are to be terminated at this stage. The data for the laser will define a path to be drawn onto the work surface and perhaps numerical or text information to be displayed.

Several types of line structure can be drawn by the laser including continuous, dashed or dotted lines. Also a short line, a snake, can be displayed which moves along the full path of the wire. The reason for using these different displays is to improve

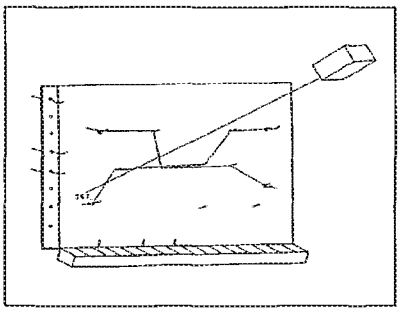


Figure 1. Workstation with Wire Feeds, Component Bins and Laser Display Indicating the Number, Wire End and Bins

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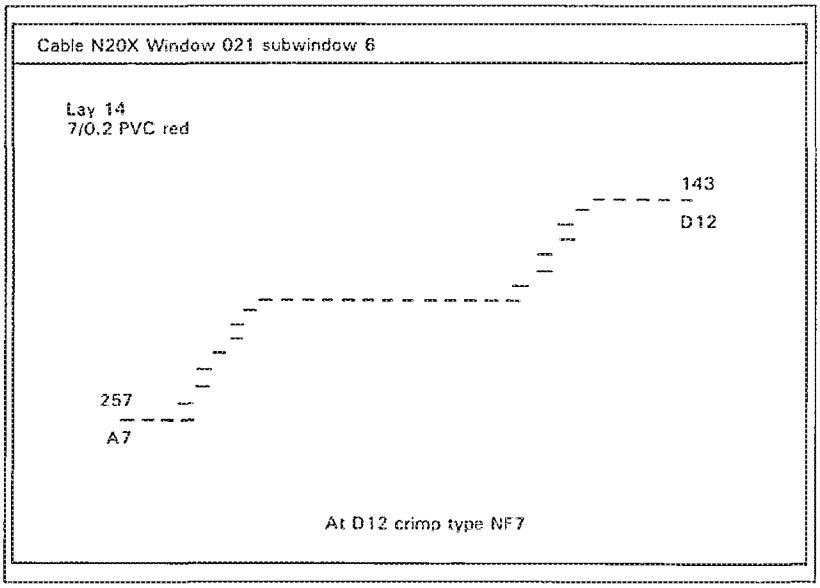


Figure 2. Operator's Monitor Display Showing that the Identity Sleeves for 257 are to be Fitted to the End at Position A7.

the visibility of the lines, particularly when a large number of wires have been laid. If the path is long, a full line may not be bright enough or flickering can occur due to the longer time required to draw the line.

Each operator has a PC with a monitor and simplified keyboard. The data file may be transferred from a disk or a central database. Each window can be displayed as "subwindows". These show the information of the window but use colour changes to highlight particular stages in laying, marking or terminating that wire. For example, in the figure shown, the reference to the crimp connector will change colour when the correct subwindow is reached. An appropriate display by the laser is associated with each subwindow. For laying the wire the path of the wire is drawn on the work surface and for fitting the identification sleeves the number is drawn by the end of the wire. Thus the information is displayed where the work is being done and the risk of error is reduced. The operator moves forward through the subwindows and windows by hitting a single key or footswitch. Each window is marked in the stored data and on the screen when the operator signals that its task has been completed. It is then possible to check that no stages have been omitted and to restart at the correct stage after an overnight break. The other keys allow jumps to other parts of the program, forwards or backwards. Before a cableform is started, alignment of the laser and pin board, on which the cable is made, is achieved by aligning marks on the board with spots projected by the laser.

The laser system can be used in other ways to assist the operator. The ends of the wires from the storage reels can be brought to the edge of the work surface and the laser can point to the wire to be taken. Also, with the identity sleeves in boxes by the work surface, the laser can point to the end of the wire and to the sleeves in the order that they are to be placed on the end of the wire. When it is important that certain facts or warnings are brought to the attention of the operator these can be displayed by the laser or the laser can point to messages printed on the work surface.

The equipment used to set up the data file is similar to that used by an operator but has a full keyboard and a mouse. The windows to be used by the operator are built up by using the mouse and menus displayed with the windows. Laser paths can be drawn on the work surface by using the mouse to move the spot, and these paths can be modified by using the mouse and displayed menus. The same arrangement of laser and work surface is used for each work station and it is not necessary to make corrections for the geometry of the projector. The positions on the board are automatically stored as deflector co-ordinates. Laser paths are automatically displayed on the monitor. The monitor cursor can be controlled by the mouse and text added at the cursor position. It is possible to arrange that selected text be displayed by the laser. Existing files can be modified by the addition, modification or deletion of windows.

The visibility of the laser spot is adequate provided that the ambient lighting is not too bright. The visibility would be improved if a cheap laser with a colour nearer to the centre of the visible spectrum than the red He-Ne, were available. Such lasers should be available in the next few years. The power of the laser is low enough to make it safe in this application. Lasers can be dangerous if one looks directly along the beam into the laser or a beam reflected from a shiny surface. In this system, while the deflection system is moving the beam, the dwell time in the eye is negligible and a shutter can be incorporated to cut off the beam when it is at rest. It should be remembered that it is not a unique property of lasers to be dangerous; any light source which produces an intense spot of light can be dangerous if that spot remains on the iris of the eye.

This system for the manufacture of cableforms reduces the risk of expensive errors and also the time taken to follow data sheets. The information is presented clearly, in digestible amounts, where the work is being done. There is no advantage in learning the data for a particular cableform and therefore "batches of one" can be made. There are other applications where one operator has to perform a series of operations too long to be learned. For these similar computer based systems could be used with advantage, although not all would need the use of a laser projector. An alternative to the use of a laser projector, when the high resolution of the laser is not required, is to use a liquid crystal transparency in a diascope projection system similar to that used with overhead projectors at lecture presentations.

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LASER PROJECTION LINKS COMPOSITE DESIGN TO MANUAL FABRICATION

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SUMMARY : This paper baselines the current state of methods and applications that employ computer data to direct composite manufacturing processes. Industry needs, emerging solutions, and potential research to advance these technologies are addressed. It contrasts today's processes to laser based virtual operator assistants and encourages scientific exploration and developments to maximize the utilization computer model data for minimum product costs. Computer graphics for design and analysis is creating extensive electronic data for product definition. The improved visualization, simulation and accuracy of 3-D images is enhancing quality and reducing design costs. Laser Projection is emerging as a viable method to clearly and accurately display computer model data for worker instructions.

Applications are expanding. Today laser images direct manual cutting, pickup, and placement of composite laminates. Tomorrow they will provide complete identification, validation, inspection, and assembly guidance. This technology may truly represent the missing link between human operators and computer data.

KEYWORDS: Laser, Low-cost, Manufacturing, 3-D, Industry Needs, Layup, Inspection, Cutting, Kits, Identification

INTRODUCTION

The same model data that is used to define products can often be reused with little or no modification as direct input to numerically controlled factory equipment for milling, drilling, painting, or composite tape and tow placement. Unfortunately only a small percentage of the total manufacturing processes, normally those which are performed by numerically controlled machines and equipment, can benefit from the multiple use of data that was produced for design or analysis. The rapid expansion in the quantity of new products being designed by computer aided design systems coupled with the limited direct links to manufacturing processes is leading to an increase in the use of "human interfaces" between computer databases and manufacturing processes. This means that increasingly large amounts of structured data is being created to optimize the design process and left for human interpretation and translation into manufacturing instructions, specifications, and controls.

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Even though, very complete and often complex computer models exists for a product the output of the CAD system is all too often a paper printout. These documents generally come in the form of drawings, work instructions, specifications, etc. Some are electronically transferred directly from the design model but most are recreated by the engineers and analyst after viewing and studying the computer model. They convert the images and text that they see into written or graphic requirements and instructions for factory personnel to subsequently view again and interpret as they are applied to the product. Tooling and Planning Engineers use similar methods to concept, define, and design tools to control processes or product configuration. The time spent viewing, analyzing, and regenerating this data for instruction is essentially non-value-added work. Clearly there must be a better way for this data to be converted into information and methods that can be used to improve manufacturing cost and quality of products without these labor intensive efforts.

Locating computer terminals in the factory work area is a step in the right direction, but this solution still falls short of the ultimate goal of a direct link between the source of the data and the user. Often monitors can not be located at the point of use thus further contributing to non-value-added work by forcing the user to leave the work area or at least break the concentration and rhythm that is present during highly productive work just to read the next set of instructions.

"Immersive technologies" may hold the answer to accurately and rapidly conveying 3-D computer instructions directly to a person at work in a factory environment. Imagine a work cell where 3-D data could be extracted from the product design and process simulation model and then be projected to represent precise full-size images in a manner that would guide and direct the worker through every task. This same system would sense all changes to the work cell environment. No, this is not impossible as a matter-of-fact elementary factory level immersible work cells are in active production for the manual layup of composites today.

LASER PROJECTION LINKS COMPOSITE DESIGN TO MANUAL FABRICATION

The development and acquisition of robotics and automated or numerically controlled machinery for composites can be very costly. In addition to the high procurement costs many past development attempts have been only marginally successful. For this reason even though the manual lay-up process for composites is labor intensive and error prone it remains as today's dominate fabrication method. As composite usage increases the high cost battle of technology versus labor continues to escalate.

The defense industry is still working to overcome the technical limitations of automated mechanical solutions. Meanwhile, weapon manufacturers continue to increase the use of composite materials to meet performance requirements. They are constantly plagued by the high production costs of these new materials. Declining production rates and order quantities further compound the composite automation problem. Smaller contract quantities and slower rates increase the investment risks of large scale fixed assets and automation developments. These same factors are driving industry to adopt Lean Production [1] principals to combat increasing competition for market share. Lean Production eliminates non-value-added work and equipment. Throughput speeds are increased and costs are reduced. Examples of non-value added work for composites include extensive analysis, setup, inspection, support and discrete part tooling.

Laser projection systems[2] are being developed as near term low risk solutions to eliminate much of this non-value-added work while maintaining a man-in-the-loop to overcome the physical limitations of robotic equipment. Robots have been used more successfully to assist rather than replace technicians. This had led to the development of systems to reinforce the operator with virtual operator assistants that greatly speed up manual processes. For example, Laser projection systems (Fig.1) are being used to illuminate the work area with precise full size images of composite work-pieces at sequential in-process states of completion.

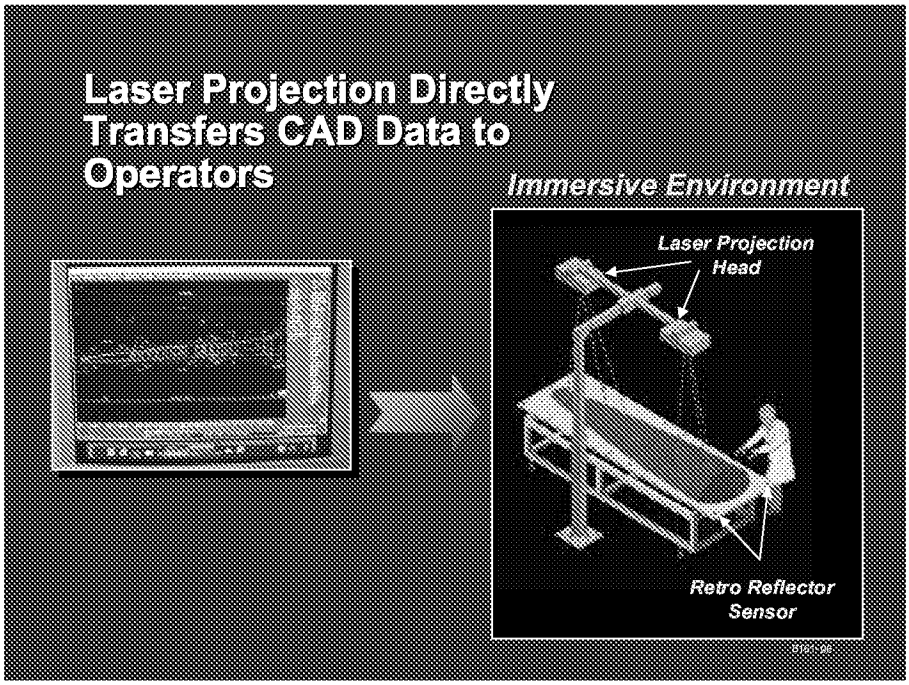


Figure 1: Laser Projector

The profile, orientation and identity of each composite ply is projected onto flat or compound contoured tools and subsequently onto the previously laid composite plies. Some of the systems are self-aligning to sensors located on the tools thus avoiding non-value-added setup. The lay-up technicians use hand held infrared remote control units to move rapidly through the 3-D CATIA database. The laser projector becomes the mechanism to convert the work area into a combination physical and virtual workspace. The operator experiences instantaneous life size work instructions. Precise profiles of each ply are projected onto the tool along with the identification number and fiber direction. This provides a visual verification and match of the precut ply profile and fiber orientation to the design database. The speed and accuracy of these full size visual placement instructions eliminate the "think time" and errors normally associated with the manual process. Once a ply is in place or an operation is complete the operator calls for laser verification of the ply placement. The laser projects acceptance or rejection of the ply position and the operator uses the remote control unit to request subsequent instructions to continue. Immediately the next image is displayed. The time and costs related to overlay templates and tedious measurements are eliminated. Lay-up speed is greatly increased and the associated throughput time is proportionately decreased. The laser projector is truly a flexible "Lean Production" machine. This eliminates tools, setup, and drawing interpretation errors while speeding up throughput and improving part quality. The early success of systems like this has led to the identification of several follow-on applications for near term implementation.

Compared to the traditional method for composite layup this process eliminates essentially all of the non-value-added-work. (Fig.2) The time previously required for a layup technician to analyze the drawing and specifications, read and understand the work instructions, position tooling templates, find an inspector, and wait for him to measure the ply placement is eliminated. (Fig.3)

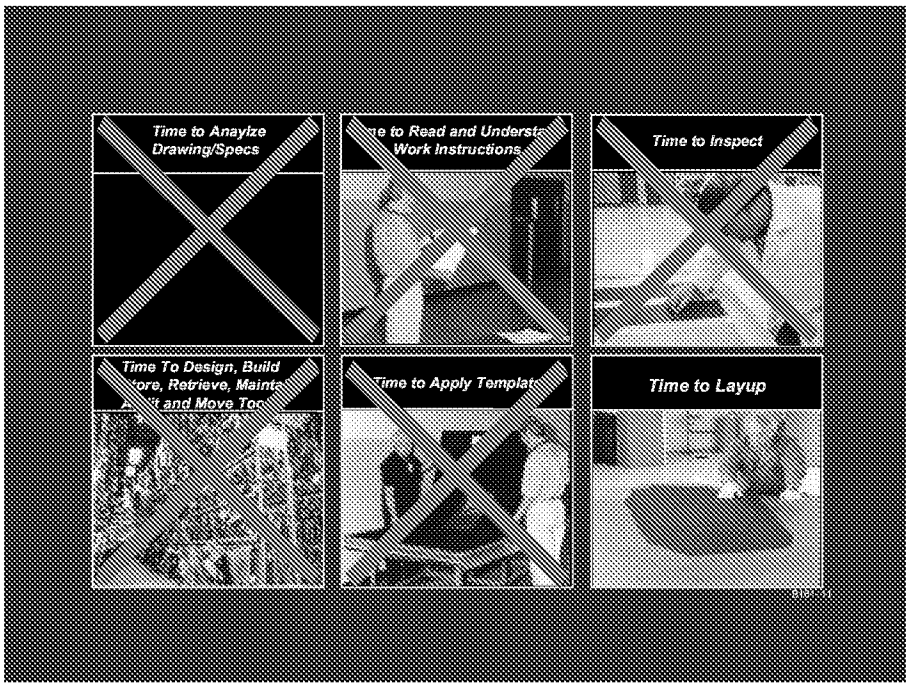


Figure 2: Elimination of Non- Value- Added- Work and Tools

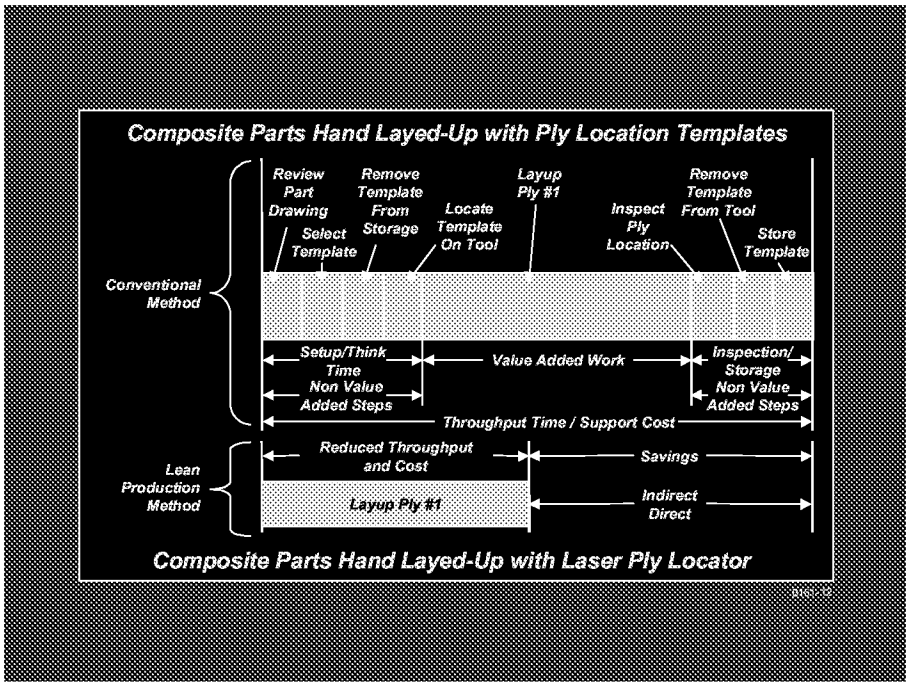


Figure 3: Savings from Laser System

EMERGING APPLICATIONS:

Composite Ply Cutting-
A new laser projection system is being developed to streamline the process for kitting and stacking cut plies in the proper sequence for layup. A projector similar to the one used in the lay-up cell is mounted in the ceiling above the automated flat bed composite cutter. The computer product model data is converted to flat patterns, sequenced, nested, and downloaded to the cutter controller. Approximately 40 feet of composite material 8 feet wide is pulled from the roll and vacuumed securely to the cutter bed. An ultrasonic knife rapidly cuts the material into dozens of discrete shapes. The operator quickly removes all of the cut pieces from the bed without regard to sequence. This allows the cutting of the next nest to begin. The process of resorting, sequencing, and stacking into orderly lay-up kits is then performed concurrent with the cutting.

Once the laser pointer system is operational this task will be eliminated. The material will be cut as before. Instead of random pickup of the cut plies the overhead laser will guide the operator by painting lines around the ply to be selected from the nest in the proper kit stack sequence. As the ply is removed from the cut nest the laser senses the operators hand movement and immediately draws a line to and around the periphery of the next ply in the proper pick and stack sequence. This point and pick process is repeated in rapid succession. Following the removal of all plies the cutting of the next nest can begin. This method will reduce the labor of sorting, the errors that result from improper sequencing, and provide orderly kits directly from the cutter that are ready to be moved as a group to the lay up cell.

Laser projection can greatly speedup cutting, kitting, lay-up and at the same time enhance the quality of composite components. The associated throughput time is proportionately decreased. It eliminates tools, setup, and drawing interpretation errors while speeding up production, improve product quality and combat the high costs of composites production.

The potential for wide use of this concept in manufacturing warrants additional expansion of laser projection and new development of associated technologies to enable the creation of immersive environments for factory level functions. The early success of these pilots has led to the recognition and identification of several follow-on applications that are maturing for near term implementation.

Painting-
Laser projection is in the trial evaluation and demonstration phase for guiding workers to precisely locate precut decals onto the outside of aircraft. A related but potentially much higher volume use of this technology involves pre-cutting large quantities of colored adhesive film materials to completely cover the outside of an aircraft thus eliminating the environmental hazards associated with application and removal of paint.

FUTURE APPLICATIONS:

Assembly Kit Buildup-
Projection technology is also envisioned as a means to guide an operator to select, sequence and place the components into an assembly kit. Take this development one step further and use the laser to reduce or even eliminate the need for assembly fixtures by providing precise projections for component location. The projection could even include highlighting of the current component of interest, sequentially guiding the installation, methods and even instructions for operation and testing of the functionality.

Wire Harness Fabrication-
Today most wire harnesses are developed and assembled on wire form boards. The boards support the wire bundle as the individual wires are added. The termination points are normally identified on the board and the wire ends are generally clamped or otherwise secured to the board. Locating the proper wire terminals for a specific wire can be labor-intensive. All too often the sequence of routing and even the path is left up to the wire routing technician. This can result in wires of varying lengths and more non-value-added work for the technician. A projection system could eliminate the searching for wires and terminals, standardize the routing sequence, rapidly point to the starting and ending terminals and illuminate the best route for the wire.

Fastener Installation-
One would imagine that the process for an aircraft mechanic to manually install a single fastener in an array of other fasteners would be straight forward and relatively simple but the variety of fasteners, processes and tools required can be mind-boggling. A typical scenario would begin with establishing the location, type of fastener, nut, washer, spacer etc. The operator must then determine the size and type of drill bit, the drill motor type and size, type and size of reamer, type and size of countersink, feed, speed, or other special operation instructions. Finally the hole is drilled and possibly reamed or maybe step-drilled. The hole must now be de-burred. This often requires parts to be separated de-burred and then reassembled. If required sealant must be added to the hole, the appropriate wrench, socket and/net runner selected and the fastener is finally installed. Imagine the opportunity for errors, the amount of non-value-added work, and the almost unbelievable "think time" associated with searching for the correct components, processes, or for determining the proper sequence as this scene it repeated thousands of times for a typical aircraft assembly. Virtual immersive factory workstations could eliminate most and in some cases all of the non-value-added work associated with this job.

Inspection-
The use of ultrasonics and real-time x-ray for non-destructive inspection are providing the ability to peer past the surface of both metal and composite structures. Operators can even establish 3-D definitions of internal anomalies or areas of interest. Unfortunately, the output from most of these systems is also limited to printouts, photos or CRT images. Often this form of output can provide extremely clear images of the anomalies but they can require extensive efforts to accurately relate the area of interest directly to the component that was evaluated. In addition to being tedious this process is also prone to positioning and location errors when the areas of interest are superimposed and marked on the component being inspected. This is another potential application where Projection Technology could provide immediate and accurate feedback to enable the scanning technician to precisely an instantaneously locate the area of interest or anomaly on the surface of the components being imaged thus eliminating errors, reducing costs and speeding the process for repairs.

As we look to the future perhaps it is best to categorize, combine, and generalize applications as a means to identify and address the generic technological needs to enable virtual factory floor work instructions to become a reality. Perhaps one of the best ways to illustrate and understand the needs would be to begin by imagining a worker performing essentially any task surrounded by a realistic, full-size, 3-D in-process virtual image. Further reality is added to this scene by the inclusion of multimedia text and sound to provide clear and concise visible and audible work instructions. These highly sensory instructions are delivered directly to the point of use without the worker leaving the area or even looking away from the job at hand. They are interactive. As the worker completes a task or a physical component replaces a virtual component the virtual image is automatically updated to lead the worker through the next task. The active virtual components are highlighted to depict the exact positioning and manipulation required by the worker. This life size dynamic interactive simulation would continue until all tasks are complete. Even though this concept seems futuristic a large portion of the enabling technologies are already at various levels of development or implementation in other applications or less hostile environments.

TECHNOLOGY DEVELOPMENT NEEDS:

Many of the technologies required to implement a virtual factory workplace are available. However additional research and development is needed to exploit this process to its fullest potential. One of the biggest technological challenges is how to satisfy the need for high-resolution display of text and fine lines in natural day or artificial light. The current use of lasers to rapidly project single lines into the work area is highly analogous to the use of vector graphics 15 years ago. At a time when vector technology seemed to open the door for 3-D design and simulation the size the models and the physical limits of the vector displays appeared to create a barrier to the imagined growth for this exciting new tool for engineering and design. Fortunately raster graphics technology came to the rescue, eliminated the flicker problems, and made realistic shaded 3-D solid images possible.

The stage is set and the need is emerging for similar advancements to make the 3-D workspace a reality. Likewise the change from a limited quantity of color vectors to multicolor life size images is needed to not only add realism and clarity but also to allow instruction projections to appear as computer generated solid models overlaid on physical components in the virtual factory workplace.

In order to be an effective virtual tool the worker must be able to move freely about the workspace without ancillary equipment, umbilical wires or other constraining or limiting equipment. The visibility must remain constant as the user moves through the workspace. This means that multiple concurrently synchronized projectors or lens must be placed around the space to eliminate shadowing of the virtual model.

In order to achieve a truly interactive environment between a user and the model data database sensors and software must be developed to constantly monitor changes in the workspace and correlate the environment to the database. In addition to methods for communicating the environment to the system sound and voice are needed for the virtual operator assistant to provide directions to the human operator and from the human operator to the virtual assistant. This too must be accomplished in a manor that does not constrain the user but that can overcome the interference and harsh environment of a factory work area.

The potential of this technology can be far reaching. The creation of a true virtual factory workspace may seem futuristic but both the foundation for the technologies and the need exists. Laser projection technology even though limited in its resolution has demonstrated a near term practical application as well as a need for advancement of the concept of humans working interactively in a hybrid of physical and immersive computer environments.

Holograms are becoming commonplace for entertainment and toys. Small displays are extremely realistic. They can even be created with special shaped mirrors that project lifelike images using only the light gathered from the room. These 3-D solid appearing images seam to float in space above or in front of the mirrors [3].

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The size and dynamics of 3-D holograms is increasing. The automotive industry took a major step in January 1999 by producing a large hologram for promotional advertisement at the North American International Automotive show in Detroit[4]. The display featured a realistic 1/2size engineering concept of an automobile that hasn't been built. Full-size holograms are near and with proper direction of Research, Development and Implementation of laser projection and the enabling technologies outlined in this paper full-size Virtual Factory Workspaces linked directly to the product design should not be far behind!

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Electronic Patent Application Fee Transmittal

Application Number:	15600054
Filing Date:	19-May-2017
Title of Invention:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Paul Ryznar
Filer:	Karl T. Ondersma/Leslie Vredeveld
Attorney Docket Number:	RYZ01 P-101B

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 2 months with $0 paid	2252	1	300	300
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	2806	1	120	120
		Total in USD ($)		**420**

Electronic Acknowledgement Receipt

EFS ID:	35806719
Application Number:	15600054
International Application Number:	
Confirmation Number:	6939
Title of Invention:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Paul Ryznar
Customer Number:	15671
Filer:	Karl T. Ondersma/Leslie Vredeveld
Filer Authorized By:	Karl T. Ondersma
Attorney Docket Number:	RYZ01 P-101B
Receipt Date:	23-APR-2019
Filing Date:	19-MAY-2017
Time Stamp:	16:09:16
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Payment Type	CARD
Payment was successfully received in RAM	$420
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Information:					
2	Amendment/Req. Reconsideration-After Non-Final Reject	02-ResponseA.pdf	51575 8034462dd9eda9e81503d963ac2a564b62158554	no	8
Warnings:					
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3	Information Disclosure Statement (IDS) Form (SB08)	03-SIDS.pdf	612701 e5ba4b6beb99f0e5fc82fc5c057b5b8d82c5d0bd	no	4
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5	Non Patent Literature	NPL02-OptimalWorkerAssistanceFramework.pdf	1383864 6fd0196c4f3a775fedc29b3b0ae1c4301d39e8bf	no	6
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6	Non Patent Literature	NPL03-ImprovingManualManufacturing.pdf	3293662 cbc182c899b3dab2c8a25d9cdd27d58b0b042676	no	9
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7	Non Patent Literature	NPL04-LaserGuidesManualAssembly.pdf	831321 dd81149ccf34cfa0ef928ea772d4631448a0c74a	no	3
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<u>National Stage of an International Application under 35 U.S.C. 371</u>
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<u>New International Application Filed with the USPTO as a Receiving Office</u>
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): RYZ01 P-101B

Application Number: 15/600,054

Filed: May 19, 2017

For: LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

Art Unit: 2116

Examiner: Paul Ryznar

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

		Fee	Small Entity Fee	Micro Entity Fee	
☐	One month (37 CFR 1.17(a)(1))	$200	$100	$50	$
☑	Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$ 300.00
☐	Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐	Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐	Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 505553.

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I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71. 37 CFR 3.73(b) statement is enclosed (Form PTO/SB/96).

☑ attorney or agent of record. Registration number 55894.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Karl T. Ondersma/ — Signature

April 23, 2019 — Date

Karl T. Ondersma — Typed or printed name

616.975.5500 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PATENT
RYZ01 P-101B

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Confirmation No.	: 6939
Group Art Unit	: 2116
Examiner	: Christopher E. Everett
Applicant	: OPS Solutions LLC
Serial No.	: 15/600,054
Filed	: May 19, 2017
For	: LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
Customer No.	: 15671

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir or Madam:

RESPONSE

Responsive to the Office Action mailed November 23, 2018, Applicant wishes to amend the application as follows:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 5 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions and listings of claims in the present application:

1. (Original) A guide system adapted to provide visual indicators to an individual to guide actions for a particular guided operation, said guide system comprising:

a directional light device, said directional light device being selectively operable to project and target at least one indicating light;

a guide system controller, said guide system controller being operable to control said directional light device to project a visual indicator onto a physical object associated with the particular guided operation;

a camera located proximate to said directional light device and configured to image said visual indicator when projected onto the physical object;

a monitor, said monitor being remote from said directional light device and said guide system controller, with said monitor being operably interfaced with said camera to display images from said camera.

2. (Original) The guide system of claim 1, wherein said guide system controller is configured to be selectively interfaced with a computer, said computer being remote from said directional light device and said guide system controller, with said monitor interfaced with said computer and with said computer configured to selectively operate said guide system controller.

3. (Original) A method of projecting visual indicators to guide actions of an individual for a particular guided operation, said method comprising:

projecting a visual indicator using a directional light device onto a physical object associated with the particular guided operation;

imaging the projected visual indicator with a camera located proximate to the directional light device;

transmitting images from the camera to a monitor located remotely from the directional light device; and

displaying images from the camera on the monitor.

4. (New) The method of claim 3, wherein said imaging, by the camera, captures images of at least the individual being guided, the physical object and the projected visual indicator.

5. (New) The method of claim 3, further comprising receiving, by the guide system controller, a sequence of one or more input signals and prompting the directional light device to project the visual indicator for the particular guided operation.

6. (New) The method of claim 5, wherein the sequence of one or more input signals are provided by a separate computer system or controller to the guide system controller.

7. (New) The method of claim 3, further comprising receiving, by the guide system controller, a sequence of input signals and prompting the directional light device to dynamically project a sequence of visual indicators onto the physical object for the particular guided operation based on the sequence of the input signals.

8. (New) The method of claim 7, further comprising receiving, by the guide system controller, a combination of the sequence of the input signals and generation of a dynamic, real-time projection, via the directional light device, of the sequence of said visual indicators.

9. (New) The method of claim 8, wherein the sequence of input signals are provided by a separate computer system or controller to the guide system controller.

10. (New) A guide system adapted to provide visual indicators to an individual to guide actions of the individual for a particular guided operation, said guide system comprising:

a directional light device, said directional light device being selectively operable to project and target at least one indicating light;

a guide system controller, said guide system controller being operable to control said directional light device to project a visual indicator onto a physical object associated with the

particular guided operation;

a camera located proximate to said directional light device and configured to capture an image of at least the individual, the physical object and said visual indicator when said visual indicator is projected onto the physical object;

a monitor, said monitor being remote from said directional light device and said guide system controller, with said monitor being operably interfaced with said camera to display the image captured by said camera.

11. (New) The system of claim 10, wherein said guide system controller is configured to receive a sequence of one or more input signals causing said directional light device to project said visual indicator for the particular guided operation.

12. (New) The system of claim 11, further including a separate computer system or controller and wherein said separate computer system or controller is configured to provide the sequence of one or more input signals to said guide system controller.

13. (New) The system of claim 10, wherein said guide system controller is configured to receive a sequence of input signals and to cause said directional light device to dynamically project a sequence of visual indicators onto the physical object for the particular guided operation based on the sequence of the input signals.

14. (New) The system of claim 13, wherein a combination of the sequence of the input signals results in a generation of a dynamic, real-time projection of the sequence of said visual indicators.

15. (New) The system of claim 14, further including a separate computer system or controller and wherein said separate computer system or controller is configured to provide the sequence of input signals to said guide system controller.

REMARKS:

Applicant acknowledges with appreciation the Examiner's review of the specification, claims, and drawings. In light of the above amendments and following remarks, Applicant respectfully requests reconsideration of the present application. The amendments and remarks presented herein are believed to be fully responsive to the Office Action, dated November 23, 2018 (hereinafter the "Office Action"). Further, the amendments presented herein are fully supported by the application as originally filed. No new matter has been added. Accordingly, reconsideration is requested.

Claims 1 – 15 are pending in the application, with claims 1 – 3 having been originally presented and new claims 4 – 15 having been added, as set forth above.

Claim Rejections under 35 U.S.C. § 102 and §103

Claims 1 and 3 were rejected under 35 U.S.C. §102 as being unpatentable by Engelbart et al. (U.S. Pat. Pub. No. 2005/0225753) (hereinafter "Engelbart").

Claim 2 was rejected under 35 U.S.C. §103 as being unpatentable over Engelbart in view of Wechter et al. (U.S. Pat. Pub. No. 2011/0178627) (hereinafter "Wechter").

Applicant respectfully traverses the rejections because there are claim limitations in claims 1 and 3 that are not disclosed or suggested by Engelbart.

Claim 1 specifies a guide system to provide visual indicators to an individual to guide actions for a particular guided operation. The system includes a directional light device and a guide system controller, with the controller being operable to control the directional light device to project a visual indicator onto a physical object associated with the guided operation. Moreover, a camera located proximate to the directional light device is configured to image the visual indicator when projected on the object. A monitor is provided remote from the directional light device and guide system controller, with the monitor interfaced with the camera to display images from the camera. Accordingly, the system includes a controller for projecting visual indicators onto an object for guiding an individual, with the camera configured to image those visual indicators, and a monitor interfaced with the camera to display images from the camera.

In contrast, the camera of Englebart does not image visual indicators. Rather, as discussed in more detail below, Englebart includes general lighting to illuminate a composite

structure with a camera viewing the composite structure to locate defects in the composite structure. Subsequently, in another step after the defects have been identified, light is projected at the defects to enable them to be repaired. Englebart for example is thus not understood to use the camera to image the light projected at the defects, but rather merely to record images of the composite structure for subsequent identification of the defects.

Specifically, Engelbart aims to provide a system and a method for using light to indicate locations of flaws and defects on a composite structure (para.0034). The system of Engelbart includes a light source and a controller associated with the light source to emit a light for illuminating a composite structure (para.0036) and a camera connected to a processor for capturing images of the composite structure being illuminated and interpreting the images (para.0092) to determine a location of a defect (para.0094). The defect location information is then stored in memory so that the location information can subsequently be used to locate the defect at a separate re-work operation by illuminating the defect according to location information stored in memory (para.0036). Accordingly, Engelbart utilizes the camera and light to (1) illuminate the composite structure for the purpose of capturing images, identifying defect location(s) and storing the locations in memory (paras. 0092 and 0094) and, subsequently, (2) projecting the light onto the defect(s), based on the stored locations, to make defect(s) readily identifiable for later action, such as defect repair and/or FOD removal by an operator (paras.0035, 0048 and 0088).

By contrast, independent claim 1 of the instant application recites both an ***indicating light*** and a *visual indicator* and that

> *a camera ... configured to image said visual indicator when projected onto the physical object*

Applicant respectfully submits that Engelbart at least does not teach or suggest that the camera described in Engelbart is configured to image a visual indicator when the visual indicator is projected onto a physical object, or the composite structure, as described by Engelbart.

Accordingly, for at least the foregoing reasons, reconsideration and withdrawal of the rejection of claim 1 under 35 U.S.C. §102 is respectfully requested, as well as the rejection of claim 2 depending therefrom.

Although varying in scope, independent claim 3 recites a similar claim limitation as in claim 1, which is not taught or suggested by Engelbart for the reasons described above. Thus, reconsideration and withdrawal of rejection of claim 3 under 35 U.S.C. §102 is also respectfully requested.

New Claims:

New claims 4-9 depend from independent claim 3 and are directed to further aspects of the method, and are fully supported by the application as originally filed.

New claim 4 specifies that the camera captures images of at least the individual being guided, the physical object and the projected visual indicator. Support for this claim is found in, for example, paragraph [0091] of the published application.

New claims 5-9 are directed toward methods in which the guide system controller receives input signals and the directional light device projects visual indicators accordingly, and that the input signals are provided by a separate computer system or controller to the guide system controller. Support for these claims is found, for example, in paragraphs [0073]-[0078] of the published application.

Applicant further submits that new claims 10-15 are supported by the application as originally filed, with independent claim 10 being directed to a guide system including a directional light device, a guide system controller, a camera located proximate to the directional light device and a monitor remote from the directional light device. The camera is configured to capture an image of at least the individual, the physical object and the visual indicator when the visual indicator is projected onto the physical object, and the monitor is operably interfaced with the camera to display the image captured by the camera. Claims 11-15 depending therefrom further specify aspects related to the guide system controller being configured to receive a sequence of input signals causing the directional light device to project the visual indicator for the particular guided operation, and the inclusion of a separate computer system or controller configured to provide the sequence of input signals to the guide system controller

Claims 1 – 15 are pending in the application. Applicant respectfully submits that independent claims 1 and 3 are neither disclosed nor suggested by the cited references such that they are in condition for allowance, along with the claims depending therefrom, and a notice to that effect is earnestly and respectfully requested.

The Examiner is invited to contact the undersigned at (616) 975-5500 should there be any questions or suggestions.

Respectfully submitted,

OPS SOLUTIONS LLC

By: Gardner, Linn, Burkhart & Ondersma LLP

Date: April 23, 2019

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PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/600,054	Filing Date 05/19/2017	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $40 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $210 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	04/23/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 15	Minus	** 20	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $230 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/KIM R WATSON/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/600,054	05/19/2017	Paul Ryznar	RYZ01 P-101B	6939

15671 7590 05/20/2019

Gardner, Linn, Burkhart & Ondersma LLP
2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546

EXAMINER
EVERETT, CHRISTOPHER E

ART UNIT	PAPER NUMBER
2116	

NOTIFICATION DATE	DELIVERY MODE
05/20/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

Vredeveld@gardner-linn.com
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Office Action Summary	Application No. 15/600,054	Applicant(s) Ryznar et al.	
	Examiner CHRISTOPHER E EVERETT	Art Unit 2116	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 4/23/2019.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-15 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☑ Claim(s) 10-15 is/are allowed.

7) ☑ Claim(s) 1-3 and 5-9 is/are rejected.

8) ☑ Claim(s) 4 is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 5/19/2017 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date 4/23/2019.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

1. Claims 1-15 are pending.

2. The Office Action is responsive to the communication filed on 4/23/2019.

Notice of Pre-AIA or AIA Status

3. The present application is being examined under the pre-AIA first to invent provisions.

4. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

Allowable Subject Matter

5. Claims 10-15 are allowed.

6. Claim 4 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Response to Arguments

7. Applicant's arguments filed 4/23/2019 have been fully considered but they are not persuasive.

Regarding claims 1-3, the applicant argues that the cited references do not teach or suggest the claim limitations with respect to independent claim 1 below. Independent claim 3 is substantially similar to independent claim 1. Dependent claim 2 depends from independent claims 1. The Examiner respectfully disagrees. The cited prior art describe the claim limitations as briefly outlined below and as described in the rejection of claims 1 and 3 below.

- "a directional light device, said directional light device being selectively operable to project and target at least one indicating light;" (see, e.g., Engelbart: see the light source 14 as illustrated in figure 8 and as described in paragraphs 0092, 0094; "The light source 14 is positioned to emit light for illuminating the composite structure 22. The illumination is reflected differently by defects in the composite structure than from portions of the composite structure that are defect free. For example, illumination reflecting off non-defective portions of the composite structure 22, and light that fails to reflect off of defects in the composite structure 22, or vice versa, creates visible images that can be captured by the camera 12." (emphasis added) Paragraph 0094)
- "a guide system controller, said guide system controller being operable to control said directional light device to project a visual indicator onto a physical object associated with the particular guided operation;" (see, e.g., Engelbart: "Operation 432 includes creating

instructions or commands for the light source. Creating these instructions can include accessing the part fabrication file 402. These instructions can automatically cause (e.g., activate, steer, etc.) the light source to direct light at the composite structure to highlight or indicate the location at which a defect is located. Preferably, these instructions for the light source are automatically written based on NC block information and data from the inspection/vision system." (emphasis added) Paragraph 0079; "According to another aspect of the invention, a system generally includes at least one light source and a controller associated with the light source. The controller is capable of accessing positional data defining one or more defect locations on the composite structure. Without operator assistance, the controller can automatically cause the light source to direct light at the composite structure to indicate the defect location(s) as defined by the positional data." Paragraph 0036)

- "a camera located proximate to said directional light device and configured to image said visual indicator when projected onto the physical object;" (Applicant's arguments are directed to Engelbart not teaching or suggesting a camera configured to image a visual indicator projected onto the physical object; Examiner respectfully disagrees; as described above with respect to the projection of a visual indicator, Engelbart describes directing light at the structure to highlight or indicate the location at which a defect is located (i.e., visual indicator) (see paragraph 0079) and describes the camera capturing images as illustrated in figure 8 and as described in paragraph 0092; see, e.g., Engelbart: see the camera 12 as illustrated in figure 8 and as described in paragraph 0092; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the

camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." (emphasis added) Paragraph 0092)

Accordingly, applicant's arguments are not persuasive since the cited prior art describe the limitations in these claims.

For at least these reasons, the rejection of the claims is maintained.

Claim Rejections - 35 USC § 102

8. The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

9. Claims 1 and 3 are rejected under pre-AIA 35 U.S.C. 102(b) as being unpatentable by U.S. Patent Publication No. 2005/0225753 (Engelbart).

Claim 1:

The cited prior art describes a guide system adapted to provide visual indicators to an individual to guide actions for a particular guided operation, said guide system comprising:

(Engelbart: "The method also includes automatically causing at least one light source to

direct light at the composite structure to indicate the defect location(s) as defined by the positional data. Accordingly, the light allows the defect location(s) to be readily ascertained for later action, such as manual defect repair and/or FOD removal by an operator." Paragraph 0013)

- a directional light device, said directional light device being selectively operable to project and target at least one indicating light; **(Engelbart: see the light source 14 as illustrated in figure 8 and as described in paragraphs 0092, 0094; "The light source 14 is positioned to emit light for illuminating the composite structure 22. The illumination is reflected differently by defects in the composite structure than from portions of the composite structure that are defect free. For example, illumination reflecting off non-defective portions of the composite structure 22, and light that fails to reflect off of defects in the composite structure 22, or vice versa, creates visible images that can be captured by the camera 12." Paragraph 0094)**
- a guide system controller, said guide system controller being operable to control said directional light device to project a visual indicator onto a physical object associated with the particular guided operation; **(Engelbart: "Operation 432 includes creating instructions or commands for the light source. Creating these instructions can include accessing the part fabrication file 402. These instructions can automatically cause (e.g., activate, steer, etc.) the light source to direct light at the composite structure to highlight or indicate the location at which a defect is located. Preferably, these instructions for the light source are automatically written based on NC block information and data from the inspection/vision system." Paragraph 0079; "According to another aspect of the invention, a system generally includes at**

least one light source and a controller associated with the light source. The controller is capable of accessing positional data defining one or more defect locations on the composite structure. Without operator assistance, the controller can automatically cause the light source to direct light at the composite structure to indicate the defect location(s) as defined by the positional data." Paragraph 0036)

- a camera located proximate to said directional light device and configured to image said visual indicator when projected onto the physical object; **(Engelbart: see the camera 12 as illustrated in figure 8 and as described in paragraph 0092; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**
- a monitor, said monitor being remote from said directional light device and said guide system controller, with said monitor being operably interfaced with said camera to display images from said camera. **(Engelbart: see the user interface 76 connected to the storage device 64 and processor 66 as illustrated in figure 8 and as described in paragraphs 0092, 0093; "The user interface 76 can includes a window in which an image of the composite structure is displayed for viewing by an operator or other user." Paragraph 0093; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**

Claim 3:

The cited prior art describes a method of projecting visual indicators to guide actions of an individual for a particular guided operation, said method comprising: **(Engelbart: "The method also includes automatically causing at least one light source to direct light at the composite structure to indicate the defect location(s) as defined by the positional data. Accordingly, the light allows the defect location(s) to be readily ascertained for later action, such as manual defect repair and/or FOD removal by an operator." Paragraph 0013)**

- projecting a visual indicator using a directional light device onto a physical object associated with the particular guided operation; **(Engelbart: see the light source 14 as illustrated in figure 8 and as described in paragraphs 0092, 0094; "The light source 14 is positioned to emit light for illuminating the composite structure 22. The illumination is reflected differently by defects in the composite structure than from portions of the composite structure that are defect free. For example, illumination reflecting off non-defective portions of the composite structure 22, and light that fails to reflect off of defects in the composite structure 22, or vice versa, creates visible images that can be captured by the camera 12." Paragraph 0094)**
- imaging the projected visual indicator with a camera located proximate to the directional light device; **(Engelbart: see the camera 12 as illustrated in figure 8 and as described in paragraph 0092; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**

- transmitting images from the camera to a monitor located remotely from the directional light device; and **(Engelbart: see the user interface 76 connected to and separate from the storage device 64 and processor 66 as illustrated in figure 8 and as described in paragraphs 0092, 0093; "The user interface 76 can includes a window in which an image of the composite structure is displayed for viewing by an operator or other user." Paragraph 0093; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**
- displaying images from the camera on the monitor. **(Engelbart: "The user interface 76 can includes a window in which an image of the composite structure is displayed for viewing by an operator or other user." Paragraph 0093; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092)**

Claim Rejections - 35 USC § 103

10. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made

to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

11. The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

12. Claim 2 is rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over U.S. Patent Publication No. 2005/0225753 (Engelbart) in view of U.S. Patent Publication No. 2011/0178627 (Wechter).

Claim 2:

Engelbart does not explicitly describe a remote computer as described below. However, Wechter teaches the remote computer as described below.

The cited prior art describes the guide system of claim 1,

- wherein said guide system controller is configured to be selectively interfaced with a computer, said computer being remote from said directional light device and said guide system controller, **(Wechter: see the controllers 30, 32 and the remote monitoring**

and control systems as illustrated in figure 1 and as described in paragraph 0021; "The system controller 30 may be further linked to various remote monitoring and control systems, such as for downloading from a remote location manufacturing programs, component parameters, orders for products, and so forth, and for uploading to a remote location information relating to the manufactured products, their process through the system, success or failure of various processes and tests, and so forth. The remote connections may be based upon any suitable protocol, such as existing industrial data exchange protocols, Internet protocols, and so forth." Paragraph 0021)

- with said monitor interfaced with said computer and with said computer configured to selectively operate said guide system controller. **(see the remote computer in Wechter and the monitor in Engelbart; Engelbart: see the user interface 76 connected to the storage device 64 and processor 66 as illustrated in figure 8 and as described in paragraphs 0092, 0093; "The system 10 may also include a user interface 76 that is in communication with the processor 66. The user interface can be programmed such that it can run from a wide range of software applications, including but not limited to DOS, Windows 98, Windows/NT, Windows 2000, Windows CE, Linux, Unix, and equivalents. The user interface 76 can include a display screen, such as on a computer monitor, and can also include an input device, such as a keyboard and mouse (not shown), for permitting an operator to move a cursor about the display screen and input various system settings and parameters. The display screen can also be touch-sensitive for permitting the operator to input the desired settings by manually touching regions of the display screen. The user interface 76 can includes**

a window in which an image of the composite structure is displayed for viewing by an operator or other user." Paragraph 0093; "As shown in FIG. 8, the system 10 includes at least one camera 12 and at least one light source 14. The camera 12 is connected to a processor 66 for interpreting the images the camera 12 captures, or to a storage device 64 for storing the images, or both, as discussed more fully below." Paragraph 0092; Wechter: see the controllers 30, 32 and the remote monitoring and control systems as illustrated in figure 1 and as described in paragraph 0021)

One of ordinary skill in the art would have recognized that applying the known technique of Engelbart, namely, light positioning system for quality control, with the known techniques of Wechter, namely, a manufacturing system for quality control, would have yielded predictable results and resulted in an improved system. Accordingly, applying the teachings of Engelbart to provide light and camera control for quality control with the teachings of Wechter to use remote monitoring and control for quality control would have been recognized by those of ordinary skill in the art as resulting in an improved guide system (i.e., using remote control and monitoring for a light positioning system of Engelbart based on the teachings of remote control and monitoring for quality control in Wechter).

13. Claims 5-6 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over U.S. Patent Publication No. 2005/0225753 (Engelbart) in view of U.S. Patent Publication No. 2008/0121168 (Ryznar).

Claim 5:

Engelbart does not explicitly describe a sequence of inputs as described below. However, Ryznar teaches the sequence of inputs as described below.

The cited prior art describes the method of claim 3, further comprising

- receiving, by the guide system controller, a sequence of one or more input signals and (Ryznar: "As previously indicated, control module 20 is adapted to receive a first input signal 42 regarding identification information of the work piece present at the work station. . . . Alternatively, however, a first input signal may be transmitted to a network computer system and, in response to the first input signal, the network system may provide the control module with the identification information regarding the work piece present at the work station." Paragraph 0031; "In response to the first input signal 42 received, the control module 20 outputs command signals 44, 50 to directional light devices 22, 24 along link 64 to provide visual indicators to the operator, as described in more detail below, with the command signals 44, 50 being communicated based on, at least in part, the first input signal 42." Paragraph 0032)
- prompting the directional light device to project the visual indicator for the particular guided operation. **(Ryznar: see the changing of the sequence of indicating lights based on the input signals that a proper part was selected as illustrated in figure 2 and as described in paragraph 0053; "Upon receiving confirmation signal 48a from detection device 72 signifying that the proper part was selected, control module 20**

then terminates projection of indicating light 46a and transmits command signal 50a to directional light device 24 such that indicating light 52a is projected on operational step location 54a on work piece 14 to direct operator 12 as to the proper assembly point for the selected part." Paragraph 0053)

One of ordinary skill in the art would have recognized that applying the known technique of Engelbart, namely, light positioning system for quality control, with the known techniques of Ryznar, namely, a light guided assembly system, would have yielded predictable results and resulted in an improved system. Accordingly, applying the teachings of Engelbart to provide light and camera control for quality control with the teachings of Ryznar to provide control of lighting to guide actions would have been recognized by those of ordinary skill in the art as resulting in an improved guide system (i.e., control of a light positioning system using input signals of Engelbart based on the teachings of controlling lights based on input signals in Ryznar).

Claim 6:

Engelbart does not explicitly describe a sequence of inputs as described below. However, Ryznar teaches the sequence of inputs as described below.

The cited prior art describes the method of claim 5, wherein the sequence of one or more input signals are provided by a separate computer system or controller to the guide system controller. (Ryznar: "As previously indicated, control module 20 is adapted to receive a first input signal 42 regarding identification information of the work piece present at the work station. . . . Alternatively, however, a first input signal may be transmitted to a network computer system and, in response to the first input signal, the network system may provide

the control module with the identification information regarding the work piece present at the work station." Paragraph 0031; "In response to the first input signal 42 received, the control module 20 outputs command signals 44, 50 to directional light devices 22, 24 along link 64 to provide visual indicators to the operator, as described in more detail below, with the command signals 44, 50 being communicated based on, at least in part, the first input signal 42." Paragraph 0032)

Engelbart and Ryznar are combinable for the same rationale as set forth above with respect to claim 5.

14. Claims 7-9 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over U.S. Patent Publication No. 2005/0225753 (Engelbart) in view of U.S. Patent Publication No. 2008/0121168 (Ryznar) and U.S. Patent Publication No. 2011/0178627 (Wechter).

Claim 7:

Engelbart does not explicitly describe a sequence of inputs as described below. However, Ryznar teaches the sequence of inputs as described below.

The cited prior art describes the method of claim 3, further comprising

- receiving, by the guide system controller, a sequence of input signals and (Ryznar: "As previously indicated, control module 20 is adapted to receive a first input signal 42

> regarding identification information of the work piece present at the work station. . . . Alternatively, however, a first input signal may be transmitted to a network computer system and, in response to the first input signal, the network system may provide the control module with the identification information regarding the work piece present at the work station." Paragraph 0031; "In response to the first input signal 42 received, the control module 20 outputs command signals 44, 50 to directional light devices 22, 24 along link 64 to provide visual indicators to the operator, as described in more detail below, with the command signals 44, 50 being communicated based on, at least in part, the first input signal 42." Paragraph 0032)

One of ordinary skill in the art would have recognized that applying the known technique of Engelbart, namely, light positioning system for quality control, with the known techniques of Ryznar, namely, a light guided assembly system, would have yielded predictable results and resulted in an improved system. Accordingly, applying the teachings of Engelbart to provide light and camera control for quality control with the teachings of Ryznar to provide control of lighting to guide actions would have been recognized by those of ordinary skill in the art as resulting in an improved guide system (i.e., control of a light positioning system using input signals of Engelbart based on the teachings of controlling lights based on input signals in Ryznar).

Engelbart and Ryznar do not explicitly describe dynamic control as described below. However, Wechter teaches the dynamic control as described below.

- prompting the directional light device to dynamically project a sequence of visual indicators onto the physical object for the particular guided operation based on the

sequence of the input signals. (see the input signals to display selection in Ryznar and the dynamic control in Wechter; Wechter: see the reading of tags 118 (i.e., input signals), the retrieval of product configurations with display information (i.e., display features) based on the current processing configuration (i.e., dynamically), and the display of instructions 126 (i.e., projection of visual indicators) as illustrated in figure 7 and as described in paragraphs 0033, 0034, 0044; "As noted above, a wide range of products and product configurations may be accommodated in a single assembly line, and specific instructions, parameters, components, assembly steps, and so forth may be accessed for specific products." Paragraph 0033; "Moreover, specific instructions may be provided along with illustrations of how the assembly is to proceed. As also noted above, these may be stored in one or more databases and retrieved based upon the product information, the product configuration information, and the workstation information so as to appropriately lead the operator at the multiple workstations through the desired manufacturing steps." Paragraph 0034; Ryznar: "In response to the first input signal 42 received, the control module 20 outputs command signals 44, 50 to directional light devices 22, 24 along link 64 to provide visual indicators to the operator, as described in more detail below, with the command signals 44, 50 being communicated based on, at least in part, the first input signal 42." Paragraph 0032)

One of ordinary skill in the art would have recognized that applying the known technique of Engelbart, namely, light positioning system for quality control, and the known techniques of Ryznar, namely, a light guided assembly system, with the known techniques of Wechter, namely, a manufacturing system for quality control, would have yielded predictable results and resulted

in an improved system. Accordingly, applying the teachings of Engelbart to provide light and camera control for quality control and the teachings of Ryznar to provide control of lighting to guide actions with the teachings of Wechter to use dynamic control for quality control would have been recognized by those of ordinary skill in the art as resulting in an improved guide system (i.e., control of a light positioning system using input signals and dynamic control of Engelbart based on the teachings of controlling lights based on input signals in Ryznar and the teaching of dynamic control in Wechter).

Claim 8:

Engelbart does not explicitly describe a sequence of inputs as described below. However, Ryznar teaches the sequence of inputs as described below.

The cited prior art describes the method of claim 7, further comprising

- receiving, by the guide system controller, a combination of the sequence of the input signals and (Ryznar: "As previously indicated, control module 20 is adapted to receive a first input signal 42 regarding identification information of the work piece present at the work station. . . . Alternatively, however, a first input signal may be transmitted to a network computer system and, in response to the first input signal, the network system may provide the control module with the identification information regarding the work piece present at the work station." Paragraph 0031; "In response to the first input signal 42 received, the control module 20 outputs command signals 44, 50 to directional light devices 22, 24 along link 64 to provide visual indicators to the operator, as described in more detail below, with the

command signals 44, 50 being communicated based on, at least in part, the first input signal 42." Paragraph 0032)

Engelbart and Ryznar are combinable for the same rationale as set forth above with respect to claim 7.

Engelbart and Ryznar do not explicitly describe dynamic control as described below. However, Wechter teaches the dynamic control as described below.

- generation of a dynamic, real-time projection, via the directional light device, of the sequence of said visual indicators. (see the input signals to display selection in Ryznar and the dynamic control in Wechter; Wechter: see the reading of tags 118 (i.e., input signals), the retrieval of product configurations with display information (i.e., display features) based on the current processing configuration (i.e., dynamically), and the display of instructions 126 (i.e., projection of visual indicators) as illustrated in figure 7 and as described in paragraphs 0033, 0034, 0044; "As noted above, a wide range of products and product configurations may be accommodated in a single assembly line, and specific instructions, parameters, components, assembly steps, and so forth may be accessed for specific products." Paragraph 0033; "Moreover, specific instructions may be provided along with illustrations of how the assembly is to proceed. As also noted above, these may be stored in one or more databases and retrieved based upon the product information, the product configuration information, and the workstation information so as to appropriately lead the operator at the multiple workstations through the desired manufacturing steps." Paragraph 0034; Ryznar: "In response to the first input signal 42 received,

the control module 20 outputs command signals 44, 50 to directional light devices 22, 24 along link 64 to provide visual indicators to the operator, as described in more detail below, with the command signals 44, 50 being communicated based on, at least in part, the first input signal 42." Paragraph 0032)

Engelbart, Ryznar, and Wechter are combinable for the same rationale as set forth above with respect to claim 7.

Claim 9:

Engelbart does not explicitly describe a sequence of inputs as described below. However, Ryznar teaches the sequence of inputs as described below.

The cited prior art describes the method of claim 8, wherein the sequence of input signals are provided by a separate computer system or controller to the guide system controller. (Ryznar: "As previously indicated, control module 20 is adapted to receive a first input signal 42 regarding identification information of the work piece present at the work station. . . . Alternatively, however, a first input signal may be transmitted to a network computer system and, in response to the first input signal, the network system may provide the control module with the identification information regarding the work piece present at the work station." Paragraph 0031; "In response to the first input signal 42 received, the control module 20 outputs command signals 44, 50 to directional light devices 22, 24 along link 64 to provide visual indicators to the operator, as described in more detail below, with the command signals 44, 50 being communicated based on, at least in part, the first input signal 42." Paragraph 0032)

Engelbart and Ryznar are combinable for the same rationale as set forth above with respect to claim 7.

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

15. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

a. U.S. Patent No. 7,576,727 describes using a camera to capture an image of a person and an image projected by a projector.

16. Any inquiry concerning this communication or earlier communications from the examiner should be directed to CHRISTOPHER E EVERETT whose telephone number is (571)272-2851. The examiner can normally be reached on Monday-Friday 8:00 am to 5:00 pm (Eastern).

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kenneth Lo can be reached on 571-272-9774. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Christopher E. Everett/
Primary Examiner, Art Unit 2116

Notice of References Cited	Application/Control No. 15/600,054	Applicant(s)/Patent Under Reexamination Ryznar et al.	
	Examiner CHRISTOPHER E EVERETT	Art Unit 2116	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-7576727-B2	08-2009	Bell; Matthew	G06F3/011	345/156
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Amazon Ex. 1002.0376

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	Art Unit
	CHRISTOPHER E EVERETT	2116

CPC - Searched*		
Symbol	Date	Examiner
(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001)	11/15/2018	CEE

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Search of DAV using inventors	11/15/2018	CEE
Search of EAST using inventors, assignee, and text searches	11/16/2018	CEE
Search of (G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001) using text searches	11/16/2018	CEE
Search of 700/95 using text searches	11/16/2018	CEE
Review of file history and references from parent application no. 13/98444	11/15/2018	CEE
Update of EAST and sub-class searches as described above	05/15/2019	CEE
Search of Google patent using text searches	05/15/2019	CEE
Search of Google scholar using text searches	05/15/2019	CEE

/Christopher E. Everett/ Primary Examiner, Art Unit 2116	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	Art Unit
	CHRISTOPHER E EVERETT	2116

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/Christopher E. Everett/ Primary Examiner, Art Unit 2116	

Amazon Ex. 1002.0378

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	Art Unit
	CHRISTOPHER E EVERETT	2116

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	11/15/2018	05/15/2019							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4		O							
	5		✓							
	6		✓							
	7		✓							
	8		✓							
	9		✓							
	10		=							
	11		=							
	12		=							
	13		=							
	14		=							
	15		=							

Amazon Ex. 1002.0379

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1	("7576727").PN.	US-PGPUB; USPAT	OR	OFF	2019/05/15 09:22
L2	445	("20010012001" | "20020041327" | "20020064382" | "20020103617" | "20020105623" | "20020178440" | "20030093784" | "20040046736" | "20040046744" | "4843568" | "5001558" | "5138304" | "5239373" | "5325472" | "5325473" | "5436639" | "5510828" | "5528263" | "5528297" | "5534917" | "5591972" | "5633691" | "5703637" | "5882204" | "5923380" | "5953152" | "5969754" | "5982352" | "6075895" | "6084979" | "6097369" | "6166744" | "6176782" | "6198487" | "6308565" | "6335977" | "6339748" | "6353428" | "6400374" | "6414672" | "6454419" | "6501515" | "6598978" | "6658150" | "6712476" | "6720949" | "6747666" | "7042440" | "7069516" | "7170492").PN. OR ("7576727").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/05/15 09:22
L3	74029	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:24
L4	3	2 and L3	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:24
L5	101714	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:24
L6	92	2 and L5	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:24
L7	644661	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:24
L8	277	2 and L7	US-	OR	ON	2019/05/15

			PGPUB; USPAT; FPRS; EPO; DERWENT			09:24
L9	8	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/05/15 09:25
L10	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/05/15 09:25
L11	6	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L12	7722	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L13	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L14	74029	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L15	101714	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L16	8742	L12 L13	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L17	60	L14 and L16	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L18	79	L15 and L16	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L19	133	L17 L18	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L20	644661	(guide visual indicator light projection) near4 (operator user)	US-PGPUB;	OR	ON	2019/05/15 09:25

			USPAT; FPRS; EPO			
L21	18477	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L22	249079	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L23	15	L21 and L16	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L24	18351	L20 and L22	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L25	626	L24 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L26	49	L25 and L16	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L27	172	L9 L10 L11 L17 L18 L19 L23 L26	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
L28	172	L27	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:25
L29	94	4 6	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:25
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S2	1	("20080121168").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/04/25 12:40
S3	3	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/04/25 12:41
S4	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/04/25 12:41
S5	1	("2013/0325155").URPN.	USPAT	OR	ON	2016/04/25 12:41
S6	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S7	4	S4 S5	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S8	3	S2 S4	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S9	3	S3 S4	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S10	4814	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:57
S11	1106	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:57
S12	56653	(guide adj2 (system control controller))	US-PGPUB; USPAT;	OR	ON	2016/04/25 14:00

			FPRS; EPO			
S13	72690	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S14	5833	S10 S11	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S15	572	S12 and S13	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S16	47	S12 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S17	52	S13 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S18	96	S16 S17	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S19	464998	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S20	47163	guide adj3 system	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S21	127	S12 and S13 and S19	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S22	12930	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S23	190143	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S24	12	S22 and S14	US-PGPUB; USPAT;	OR	ON	2016/04/25 14:03

			FPRS; EPO			
S25	12988	S19 and S23	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S26	617	S25 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:04
S27	48	S26 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:04
S28	2	("7515981").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/12 11:43
S29	28	("20030073541" | "2682117" | "3600785" | "3623066" | "3667104" | "3986244" | "4102568" | "4163309" | "4222036" | "4318222" | "4469553" | "4890382" | "5119536" | "5430662" | "5506641" | "5801946" | "5910894" | "6224385" | "6658218" | "7027886").PN. OR ("7515981").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:43
S30	10	("20050128437" | "20110179624" | "20110243380" | "20110314001" | "6600476" | "7515981" | "7530019" | "8027745" | "8162486" | "8199108").PN. OR ("9412053").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:45
S31	20	("20030163219" | "20040225390" | "20050058969" | "20060085088" | "4961148" | "5771043" | "6188402" | "6345207" | "6453209" | "6477437" | "6725184" | "6788987" | "6819965").PN. OR ("8027745").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:56
S32	1	("20110178627").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/12 13:53
S33	4	("7307542").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/15 10:00
S34	2	("5406176").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/15 10:06
S35	4	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/15 15:39

S36	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/15 15:39
S37	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S38	4683	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S39	1106	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S40	57264	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S41	74554	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S42	5702	S38 S39	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S43	48	S40 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S44	53	S41 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S45	98	S43 S44	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S46	478537	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S47	12652	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S48	193361	(pick place picking placing placement)	US-	OR	ON	2016/08/15

		adj4 (part component bin)	PGPUB; USPAT; FPRS; EPO			15:39
S49	11	S47 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S50	13487	S46 and S48	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S51	625	S50 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S52	50	S51 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S53	136	S35 S36 S37 S43 S44 S45 S49 S52	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S54	14	("6000801" | "6036319" | "6170163" | "6600476" | "7268893").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:21
S55	4	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/01/06 14:22
S56	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/01/06 14:22
S57	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S58	5375	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S59	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S60	60369	(guide adj2 (system control controller))	US-PGPUB; USPAT;	OR	ON	2017/01/06 14:22

			FPRS; EPO			
S61	78761	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S62	6395	S58 S59	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S63	50	S60 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S64	54	S61 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S65	101	S63 S64	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S66	504181	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S67	14080	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S68	202896	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S69	12	S67 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S70	14194	S66 and S68	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S71	625	S70 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S72	50	S71 and S62	US-PGPUB; USPAT;	OR	ON	2017/01/06 14:22

			FPRS; EPO			
S73	139	S55 S56 S57 S63 S64 S65 S69 S72	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S74	139	S73	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S77	7	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 11:29
S78	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 11:29
S79	6	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S80	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S81	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S82	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S83	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S84	8083	S80 S81	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S85	57	S82 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S86	76	S83 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29

S87	127	S85 S86	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S88	613807	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S89	17531	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S90	238507	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S91	15	S89 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S92	17380	S88 and S90	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S93	626	S92 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S94	49	S93 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S95	165	S77 S78 S79 S85 S86 S87 S91 S94	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S96	165	S95	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S97	165	S96	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S98	72	("20040111901" | "20050154431" | "20060059699" | "20060106483" | "20060185181" | "20070180674" | "20110178627" | "2682117" | "3600785" | "3623066" | "3667104" |	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:31

		"3986244" | "4102568" | "4163309" | "4222036" | "4469553" | "5341183" | "5406176" | "6000801" | "6036319" | "6170163" | "6317980" | "6600476" | "7193696" | "7268893" | "7433796" | "7463368" | "7515981").PN.				
S99	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-20110178627-$ or US-20050154431-$).did. or (US-7515981-$ or US-7463368-$ or US-7193696-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.	US-PGPUB; USPAT	OR	ON	2018/11/15 11:31
S100	9	S99 and camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 11:31
S101	1	("20050225753").PN.	US-PGPUB; USPAT	OR	OFF	2018/11/15 12:22
S102	3	((("OPS") near3 ("SOLUTIONS") near3 ("LLC"))).AS,AANM.	USPAT	OR	ON	2018/11/15 13:11
S103	8	((("RYZNAR") near3 ("Paul")) OR (("RYZNAR") near3 ("James"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2018/11/15 13:12
S104	8	S102 S103	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:12
S105	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-20110178627-$ or US-20050154431-$ or US-20050225753-$).did. or (US-7515981-$ or US-7463368-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-	US-PGPUB; USPAT	OR	ON	2018/11/15 13:29

		7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.				
S106	9	S105 and camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:29
S107	30	S105 and (camera image position)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:31
S108	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-20110178627-$ or US-20050154431-$ or US-20050225753-$).did. or (US-7515981-$ or US-7463368-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.	US-PGPUB; USPAT	OR	ON	2018/11/15 13:35
S109	30	S108 and (camera position image)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:35
S110	19	S109 and guide	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:37
S111	1	S108 and (camera adj4 guide)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:38
S112	23	S108 and (camera guide)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:38
S113	111	S96 and guide	US-PGPUB; USPAT; FPRS;	OR	ON	2018/11/15 13:41

			EPO			
S114	576917	(camera).ab.clm.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:58
S115	709872	(camera).ab,clm.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:58
S116	229216	(camera).clm.ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:59
S117	709879	S114 S116	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:59
S118	7	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 16:36
S119	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 16:36
S120	6	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S121	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S122	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S123	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S124	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S125	8083	S121 S122	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36

S126	57	S123 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S127	76	S124 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S128	127	S126 S127	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S129	613807	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S130	17531	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S131	238507	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S132	15	S130 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S133	17380	S129 and S131	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S134	626	S133 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S135	49	S134 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S136	165	S118 S119 S120 S126 S127 S128 S132 S135	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S137	165	S136	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36

S138	165	S137	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S139	165	S138	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 16:36
S140	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 12:10
S141	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 12:10
S142	8083	S140 S141	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 12:10
S143	23130	((directional visual) with (light guide)) same camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S144	8928	(((directional visual) with (light guide)) same camera).ab,clm,bsum.	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S145	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
S146	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
S147	8083	S145 S146	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S148	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38

S149	111	S148 and S144	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S150	302	S148 and S143	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S151	10	S143 and S147	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S152	6	S144 and S147	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S153	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
S154	1393	S153 and S143	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S155	362	S153 and S144	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S156	785	S153 and S148	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
S157	6	S147 and S156	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
S158	13	S151 S152 S157	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
S159	14	("7241981" | "7292269" | "7306339" |	US-	OR	ON	2019/05/14

		"8751049").PN.	PGPUB; USPAT; FPRS; EPO; DERWENT			14:31

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S75	0	(selecting one more particular addressed display features by said guide system controller from the plurality of said addressed display features based on said input signals wherein said input signals control selection of said addressed display features based on the address identifier for the said addressed display feature projecting one more visual indicators corresponding to said selected particular addressed display features onto one more physical objects associated with the particular guided operation with said guide system controller configured to control operation of said projector to project said visual indicators based on said input signals wherein said guide system controller is operative to receive any sequence of input signals from the separate computer system controller to dynamically control projection of any sequence of said visual indicators corresponding to respective said addressed display features based on said input signals corresponding to desired visual indicators for the particular operation with a combination of the sequence of input signals resulting in a creation of a dynamic real time projection of visual indicators).clm.	US-PGPUB; USPAT	AND	ON	2017/01/06 14:30
S76	0	(selecting one more particular addressed display features by said guide system controller from the plurality of said addressed display features based on said input signals wherein said input signals control selection of said addressed display features based on the address identifier for the said addressed display feature projecting one more visual indicators corresponding to said selected particular addressed display features onto one more physical objects associated with the particular guided operation with said guide system controller configured to control operation of said projector to project said visual indicators based on said input signals wherein said guide system controller is operative).clm.	US-PGPUB; USPAT	AND	ON	2017/01/06 14:30

5/ 15/ 2019 9:31:08 AM
C:\ Users\ ceverett\ Documents\ EAST\ Workspaces\ 15600054-LightGuidedOperation.wsp

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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(Not for submission under 37 CFR 1.99)

Application Number	15600054
Filing Date	2017-05-19
First Named Inventor	Paul Ryznar et al.
Art Unit	2116
Examiner Name	Christopher E. Everett
Attorney Docket Number	RYZ01 P-101B

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	8751049	B2	2014-06-10	Linder et al.	
	2	7241981	B2	2007-07-10	Hofmann	
	3	7292269	B2	2007-11-06	Raskar et al.	
	4	7306339	B2	2007-12-11	Kaufman et al.	

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Examiner Name	Christopher E. Everett
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	1	Thesis entitled, LuminAR: A Compact and Kinetic Projected Augmented Reality Interface by Natan Linder, dated August 12, 2011.	
	2	Article entitled, Towards Optimal Worker Assistance: A Framework for Adaptive Selection and Presentation of Assembly Instructions by A. Bannat et al., dated 2008.	
	3	Technical Paper entitled, Improving Manual Manufacturing with a Computer Based Laser Projection System by Scott Blake, dated October 25-27, 1993.	
	4	Article entitled, Laser Guides Manual Assembly by Arthur Browne, dated 1991.	
	5	Article entitled, Laser Projection Links Composite Design to Manual Fabrication by E. D. Ledbetter, understood to have been published in 1999.	

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Examiner Signature	/Christopher E. Everett/ (05/14/2019)	Date Considered	05/14/2019

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15600054
Filing Date	2017-05-19
First Named Inventor	Paul Ryznar et al.
Art Unit	2116
Examiner Name	Christopher E. Everett
Attorney Docket Number	RYZ01 P-101B

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Karl T. Ondersma/	Date (YYYY-MM-DD)	2019-04-23
Name/Print	Karl T. Ondersma	Registration Number	55894

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Amazon Ex. 1002.0403

RFID-**guided** robots for pervasive automation

T Deyle, H Nguyen, M Reynolds... - IEEE Pervasive ..., 2010 - ieeexplore.ieee.org

... 1353–1358. Related Work in RFID-**Guided** Robotics Page 4 ... For example, in Figure 10, the properties, **actions**, and behaviors are as follows. Properties. type stores the **object** class, such as ada **light** switch (ada stands for Americans with Disabilities Act) ...

☆ 99 Cited by 43 Related articles All 14 versions

A point-and-click interface for the real world: laser designation of **objects** for mobile manipulation

CC Kemp, CD Anderson, H Nguyen... - 2008 3rd ACM/IEEE ..., 2008 - ieeexplore.ieee.org

... For example, **lights** can be turned on and off by pointing at the switch and saying "turn on ... broadly, lasers have been successfully used by the military to mark targets for laser-**guided** weaponry [1] ... points to a **light** switch and clicks, the robot could recognize it as a **light**- switch and ...

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A Klin, W Jones, R Schultz... - ... Transactions of the ..., 2003 - royalsocietypublishing.org

... a car successfully, one could define the 'driving domain' as involving wheels, roads, traffic **lights** and other ... Rather, their models or expectations of the world follow their sali- ence-**guided actions** upon an ... 7. Series of static images of the human form rendered as point-**light** displays ...

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JM Chaquet, EJ Carmona... - Computer Vision and ..., 2013 - Elsevier

... other image sensors, selected by a hierarchal visual attention process and **guided** and processed ... **camera** calibration; attributes with information about **light** conditions such as **light** source (natural or ... to investigate how to build spatio-temporal models of human **actions** that could ...

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R Bakeman, LB Adamson - Child development, 1984 - JSTOR

... or supportive structure for infants as they begin to employ referential communicative **actions** during shared ... VCM-20N50 with Newvicon tube), capable of recording with no more **light** than is ... Periods coded as off-**camera** or adult intervention were not included in sub- sequent ...

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Time-of-flight **cameras** in computer graphics

A Kolb, E Barth, R Koch, R Larsen - Computer Graphics Forum, 2010 - Wiley Online Library

... ii) a combined HDTV/ToF **camera** and (iii) algorithms for tracking and **action** recognition with a ... However, the amplitude value corresponds to the amount of incident active **light** and thus decreases ... Two office scenes acquired using a 2D/3D **camera** combination (seen from a third ...

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Exploring bimanual **camera** control and **object** manipulation in 3D graphics interfaces

R Balakrishnan, G Kurtenbach - ... of the SIGCHI conference on Human ..., 1999 - dl.acm.org

... **Lights** and shadows are less frequently used in interactive 3D graphics because of the high computational cost ... work in bimanual user interfaces [2,5, 10, 11, 13, 15, 161 has been **guided** by the ... consisted of the cubic **object** in the centre of the display and a **light** grey wireframe ...

☆ 99 Cited by 184 Related articles All 13 versions »

Object labelling from human **action** recognition

P Peursum, S Venkatesh, GAW West... - Proceedings of the First ..., 2003 - ieeexplore.ieee.org

... Figure 7. Floor (dark red) and chair (**light** blue) labelling for all views of the same test ... Such refinement could be **guided** by both image in- formation and evidence from human activity (such ... lim- itations, such as the need for finer measurements of human body **actions** (which could ...

☆ 99 Cited by 39 Related articles All 5 versions »

Amazon Ex. 1002.0404

A **camera** engine for computer games: Managing the trade-off between constraint satisfaction and frame coherence

N Halper, R Helbing, T Strothotte - Computer Graphics Forum, 2001 - Wiley Online Library

... We emphasize **guiding camera** control by constraints; however, optimal constraint satisfaction tends to lead to the **camera** jumping around too much ... Lighting Module **light** settings set **lights** according to focus to emphasize mood ...

☆ 99 Cited by 133 Related articles All 9 versions

Experiments in socially **guided** exploration: Lessons learned in building robots that learn with and without human teachers

AL Thomaz, C Breazeal - Connection Science, 2008 - Taylor & Francis

... is pre-programmed with a suite of behaviours such as changing the colour of its **lights**, opening or ... For example, a task is considered related to TBlue if the blue **light** 'ON' is in the ... can conclude that the nature of what is learned between self-learning and **guided**- learning sessions ...

☆ 99 Cited by 58 Related articles All 10 versions

Amazon Ex. 1002.0405

Google guided light actions with camera for object and person

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About 80,400 results (0.42 seconds)

Interactive video display system
www.google.com/patents/US7259747



Grant - Filed May 28, 2002 - Issued Aug 21, 2007 - Matthew Bell - Reactrix Systems, Inc.
Computer-generated characters and virtual **objects** can be made to react to ... around the user so that that the **person's actions** are displayed around them. ... The image of the **person** is photographed by an infrared (or other non-visible **light**) **camera** 3. ..... Licensing, Llc Projected visual cues for **guiding** physical movement.
Overview · Related · Discuss

Interactive directed light/sound system
www.google.com/patents/US7576727



Grant - Filed Dec 15, 2003 - Issued Aug 18, 2009 - Matthew Bell - Matthew Bell
The **camera** is configured to view and capture information in an interactive area. ... The **actions** taken by the **object** include natural movements of the **person**, ...
Overview · Related · Discuss

Man machine interfaces and applications
www.google.com/patents/US8111239



Grant - Filed May 8, 2006 - Issued Feb 7, 2012 - Timothy R. Pryor - Motion Games, Llc
Objects can be both static and in motion, from which individual datum positions ... to a plurality of **cameras** or a single **camera** processed by a conventional PC. ... the natural **lighting** of the **object**, then the cost of specialized **lighting** required for .... the angle A and the base line would be less, to allow a larger range of **action**.
Overview · Related · Discuss

Interaction arrangement for interaction between a screen and a ...
www.google.com/patents/US9582115



Grant - Filed Jun 7, 2010 - Issued Feb 28, 2017 - Rudolf Hauke - Almeva Ag
... to all of the **cameras** for determining a position of the pointer **object** which is **guided** ... be stroboscopically illuminated with infrared **light**, and the **cameras** are sensitive to ... infrared illumination is not perceptible to **persons** standing in front of the ..... or through further interaction using **actions** performed via the pointer **object** ...
Overview · Related · Discuss

Time-of-flight camera with guided light
www.google.com/patents/US8854426



Grant - Filed Nov 7, 2011 - Issued Oct 7, 2014 - Asaf Pellman - Microsoft Corporation
The refractive diffuser guides the refracted **light** to illuminate the **camera** field of view to reduce wasted source **light**. ... surface independent of the **objects**' angular displacement relative to the **camera's** optical axis. ... **person** ... . Real time perception of and response to the **actions** of an unencumbered participant/user.
Overview · Related · Discuss

Advanced video gaming methods for education and play using camera ...
www.google.com/patents/US20080122786



App. - Filed Oct 31, 2007 - Published May 29, 2008 - Timothy R. Pryor - Pryor Timothy R
One or two or more **persons** can play, generally using one or more **cameras** to ... 4,843,568: Real time perception of and response to the **actions** of an ..... using the natural **lighting** of the **object**, then the cost of specialized **lighting** required for the ..... device for operating an additional tool axis of a **guided** by a manipulator tool.
Overview · Related · Discuss

Object detection method involves determining momentary place of ...
www.google.com/patents/DE102006013992A1?cl=en

App. - Filed Mar 22, 2006 - Published Oct 4, 2007 - Torsten Elster - Karp Gmbh
The place is automatically detected by **cameras** (3a,3b,3c). ... is set in function and the security **person** is alerted as the **object**, with risk potential, is located.
Overview · Related · Discuss

Recognition-based industrial automation control with person and ...
www.google.com/patents/US9393695

Grant - Filed Feb 27, 2013 - Issued Jul 19, 2016 - Steven J. Scott - Rockwell Automation Technologies, Inc.

Amazon Ex. 1002.0406

... range **camera** systems disposed within the industrial automation system. ... **guided** ... The humans 26 may include any **person** that may be present in the .... **light** ..... In one embodiment, a default **action** may be defined or determined ... ensuring that a **person** is not hurt or an **object** is not damaged by the ...
Overview · Related · Discuss

Iris identifying apparatus

www.google.com/patents/US20020033896



App. - Filed Jul 26, 2001 - Published Mar 21, 2002 - Kouichi Hatano - Kouichi Hatano
When the **guide lights** are all turned off, the target **person** keeps the iris identifying ... To achieve the **object**, an iris identifying apparatus of the invention ...
Overview · Related · Discuss

Specially equipped walking stick for blind person - gives all round ...

www.google.com/patents/DE4004438A1?cl=en

App. - Filed Feb 14, 1990 - Published Aug 22, 1991 - Manfred Laschuetza - Manfred Laschuetza
A further **light** sensitive sensor (2) informs the blind **person** of the ambient **light** ... Blind **person** is able to take avoiding **action** before confronting an obstical. ... **guide** .... successive measured values for the distance spatial physical **objects**, the ..... of electronic **camera** and image recognition device in car for detecting traffic ...
Overview · Related · Discuss

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Amazon Ex. 1002.0407

SoundView: an auditory **guidance system** based on environment understanding for the visually impaired **people**

M Nie, J Ren, Z Li, J Niu, Y Qiu, Y Zhu... - ... Conference of the ..., 2009 - ieeexplore.ieee.org

... is **object**-oriented and has the advantages of cheap cost, smaller size, **light** weight, low ... V. CONCLUSION We have presented a prototype auditory **guidance system**, ie SoundView, for the visually ... The whole **system** is based on a portable DSP platform with built-in power supply ...

☆ 99 Cited by 17 Related articles All 4 versions

Annotating with **light** for remote **guidance**

D Palmer, M Adcock, J Smith, M Hutchins... - Proceedings of the 19th ..., 2007 - dl.acm.org

... The GestureLaser pointer is **light**- weight and designed to operate on a car or **person**, with the ... Further experimental work includes a wearable tactile hand-**guidance system** ... coordinate **system** based on vectors from a common origin and a relative coordinate **system** based on ...

☆ 99 Cited by 31 Related articles All 8 versions »

Robot **guidance** using machine vision techniques in industrial environments: A comparative review

L Pérez, Í Rodríguez, N Rodríguez, R Usamentiaga... - Sensors, 2016 - mdpi.com

... Thus, vision **systems** for robot **guidance** generally need to obtain 3D information ... This **light** is modified by grids to create lines or bands with **lights** and shadows like a zebra (Figure 8) which are recorded by the **camera** ...

☆ 99 Cited by 60 Related articles All 9 versions »

A smart infrared microcontroller-based blind **guidance system**

AS Al-Fahoum, HB Al-Hmoud... - Active and Passive ..., 2013 - hindawi.com

... back to the receiver end, in which another lens will combine these **lights** and determine ... The position in which the **light** falls can be used to calculate the distance ( ) from ... A simple, cheap, configurable, easy to handle electronic **guidance system** is proposed to provide constructive ...

☆ 99 Cited by 45 Related articles All 10 versions »

Applications of a 3D range **camera** towards healthcare mobility aids

R Bostelman, P Russo, J Albus, T Hong... - ... Sensing and Control, 2006 - ieeexplore.ieee.org

... SR2 and emitted **light** hitting **object** (doorframe) ... successful at planning a path and for directing sound to the ears laying groundwork toward a **guidance system** for the ... However, to develop a more robust **system**, more advanced 3D imaging devices will need to be developed to ...

☆ 99 Cited by 26 Related articles All 8 versions

Blind navigation support **system** based on Microsoft Kinect

V Filipe, F Fernandes, H Fernandes, A Sousa... - Procedia Computer ..., 2012 - Elsevier

... The algorithm that deciphers the **light** coding generates a depth image representing the scene ... J. Anderson and D. Lee. Embedded stereo vision **system** providing visual **guidance** to the visually impaired. Life Science **Systems** and Applications Workshop, LISA 2007 ...

☆ 99 Cited by 95 Related articles All 7 versions »

Wearable obstacle avoidance electronic travel aids for blind: a survey

D Dakopoulos, NG Bourbakis - IEEE Transactions on Systems ..., 2009 - ieeexplore.ieee.org

... ternal to the user and/or can be carried by the user (eg, infrared **light** transmitters and ... During the **guidance** mode, the computer knows the user's destination and with a single recurring beep guides ... Video is captured with rate up to 10 frames/s, which makes the **system** real time ...

☆ 99 Cited by 469 Related articles All 4 versions

CyberCode: designing augmented reality environments with visual tags

J Rekimoto, Y Ayatsuka - Proceedings of DARE 2000 on Designing ..., 2000 - dl.acm.org

... often contain a CCD sensor with relatively high resolution as well as **lights** and optics ... museum, a visitor would be able to retrieve ID numbers, and get **guidance** information ... ticular application, CyberCode often works as a good “first approximation” and helps **system** designers to ...

☆ 99 Cited by 683 Related articles All 13 versions »

Amazon Ex. 1002.0408

Multi-**camera** networks: principles and applications

H Aghajan, A Cavallaro - 2009 - books.google.com

... to use thermal **cameras** and acoustic sensors when the weather is poor and visible **light** sensors in ... also need to be synchronized, which is a problem with a distributed **systems** flavor ... Tracking an **object** through a **system** of distributed **cameras** requires being able to match **objects** ...

☆ 99 Cited by 248 Related articles All 4 versions »

People tracking and following with mobile robot using an omnidirectional **camera** and a laser

M Kobilarov, G Sukhatme, J Hyams... - ... on Robotics and ..., 2006 - ieeexplore.ieee.org

... active research area with many successful **systems** developed, such as for museum **guidance** [1], hospital ... It can either be held constant or updated during tracking (eg if **light** conditions change ... to adopt these methods and improve the performance of the presented **system** in our ...

☆ 99 Cited by 194 Related articles All 10 versions

Amazon Ex. 1002.0409

Google light guidance system with camera for object and person

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About 91,900 results (0.43 seconds)

Optical object tracking system
www.google.com/patents/US6675040



Grant - Filed Jan 26, 2000 - Issued Jan 6, 2004 - Eric R. Cosman - Sherwood Services Ag
Camera systems in combination with data processors, image scan data, and ... Passive or active optical detection is possible via various **light** sources, reflectors, and pattern structures applicable in various clinical contexts. ... **navigation** ..... they would be well-known to a **person** of ordinary skill in the mathematical arts.
Overview · Related · Discuss

Object tracking camera
www.google.com/patents/EP1854083A1?cl=en

App. - Filed Feb 24, 2006 - Published Nov 14, 2007 - Sven Fleck - Universität Tübingen
The invention concerns an **object** tracking **camera**, comprising an image ... of **persons** / **objects** in a multi-**camera system**, when a **person** passes through the field ...
Overview · Related · Discuss

Programmable, progressive, directing lighting systems: apparatus and ...
www.google.com/patents/US8253338



Grant - Filed Jan 23, 2009 - Issued Aug 28, 2012 - Richard D. Ashoff - Richard D. Ashoff
Systems and methods for providing **guidance** and entertainment to **people** within a ... of at least one **object** or **person** walking or otherwise moving in the structure.
Overview · Related · Discuss

Emergency lighting and evacuation guidance system powered by medley ...
www.google.com/patents/US9024774

Grant - Filed May 14, 2013 - Issued May 5, 2015 - Shaobin Li - Shenzhen Guangan Fire-Fighting & Decoration Engineering Co., Ltd.
An emergency **lighting** and evacuation **guidance system** includes an ... guide and **lighting** for **people** to evacuate and escape when the electric supply is cut off. ... The main **object** of the present invention is to provide an emergency **lighting** and ..... **light** equipped with crime prevention **camera** and receptacle for charging ...
Overview · Related · Discuss

Object detection and localized extremity guidance
www.google.com/patents/US9613505

Grant - Filed Mar 13, 2015 - Issued Apr 4, 2017 - Eric Martinson - Toyota Jidosha Kabushiki Kaisha
Technology for localized **guidance** of a body part of a user to specific **objects** within a physical environment using a vibration ... This **system** uses a Kinect™ **camera** to estimate the **person's** body skeleton and generate vibrational error. .... **light** ...
Overview · Related · Discuss

Dynamic Natural Guidance
www.google.com/patents/US20140005929



App. - Filed Jun 29, 2012 - Published Jan 2, 2014 - William Gale - William Gale
The guidance command references the at least one movable **object** ... The geographic data used in conventional **navigation systems** is static. ... of at least one movable **object** may be collected by a **camera** and analyzed. .... **light** ..... tall woman with the red dress," or "turn left by the **people** with the stroller.".
Overview · Related · Discuss

Mobile device in-motion proximity guidance system
www.google.com/patents/US9674664

Grant - Filed Apr 28, 2016 - Issued Jun 6, 2017 - Damon Gene Laursen - T-Mobile Usa, Inc.
Further, the in-motion proximity **guidance system** may transmit a corrective action to a collision avoidance ... Other conventional systems provide an indication of the distance to an **object** when the vehicle is ..... 106, 204, 206, and 304 from other device, including but not limited to smart traffic **light camera** systems. ..... **person** ...
Overview · Related · Discuss

Light guiding system and a method for controlling the same
www.google.com/patents/WO2011015975A3?cl=en

Amazon Ex. 1002.0410

App. - Filed Jul 29, 2010 - Published May 12, 2011 - Engel J. Knibbe - Koninklijke Philips Electronics N.V.
According to the present invention, a **light guidance system** for adapted ... signal indicating the presence of a **person**, wherein the increasing of the **light** level is ...
Overview · Related · Discuss

Signal for identifying traffic lights for computer vision
www.google.com/patents/US20160151231

App. - Filed Jul 17, 2014 - Published Jun 2, 2016 - Javier VILLAR CLOQUELL - Kaparazoom Slu
The main signal for identifying the traffic **light** can have secondary identification signals. ... traffic **lights** for pedestrians, using an electronic urban **guidance** device with computer vision, for blind or visually impaired **people**. .... signals or other **systems** depending on the state of the traffic **light**, as shown in ...
Overview · Related · Discuss

Presence detection system and lighting system comprising such system
www.google.com/patents/WO2011098931A1?cl=en

App. - Filed Jan 28, 2011 - Published Aug 18, 2011 - Engel Johannes Knibbe - Koninklijke Philips Electronics N.V.
A presence detection **system** (1) for detecting a presence of an **object** (3), particularly a **person** or an animal or vehicle, within an area (5) divided in detection ...
Overview · Related · Discuss

Amazon Ex. 1002.0411

Google light illumination system for guided actions with camera for object and p

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About 38,200 results (0.47 seconds)

Interactive video display system
www.google.com/patents/US7259747



Grant - Filed May 28, 2002 - Issued Aug 21, 2007 - Matthew Bell - Reactrix Systems, Inc.
The video **camera** and projector operate on different wavelengths so that ... Computer-generated characters and virtual **objects** can be made to react to ... around the user so that that the **person's actions** are displayed around them. ... but are not limited to, interactive **lighting** effects for **people** at clubs or events, ... **guided** .
Overview · Related · Discuss

Interactive directed light/sound system
www.google.com/patents/US7576727



Grant - Filed Dec 15, 2003 - Issued Aug 18, 2009 - Matthew Bell - Matthew Bell
The **actions** taken by the **object** include natural movements of the **person**, ... may be an infrared video **camera** and may include its own infrared **illumination**.
Overview · Related · Discuss

Time-of-flight camera with guided light
www.google.com/patents/US8854426



Grant - Filed Nov 7, 2011 - Issued Oct 7, 2014 - Asaf Pellman - Microsoft Corporation
The refractive diffuser guides the refracted **light** to illuminate the **camera** field ... of the **objects**' angular displacement relative to the **camera's** optical axis. ... Accordingly, the intensity of illumination produced by **illumination systems** is ... **person** ..... perception of and response to the **actions** of an unencumbered participant/user.
Overview · Related · Discuss

Man machine interfaces and applications
www.google.com/patents/US8111239



Grant - Filed May 8, 2006 - Issued Feb 7, 2012 - Timothy R. Pryor - Motion Games, Llc
Objects can be both static and in motion, from which individual datum ... to a plurality of **cameras** or a single **camera** processed by a conventional PC. ... **system** . ... The power for the **lighting**, such as LEDs can generally be conveyed over the .... the angle A and the base line would be less, to allow a larger range of **action**.
Overview · Related · Discuss

Recognition-based industrial automation control with person and ...
www.google.com/patents/US9393695

Grant - Filed Feb 27, 2013 - Issued Jul 19, 2016 - Steven J. Scott - Rockwell Automation Technologies, Inc.
... or more **objects** in an industrial automation **system** and distinguishing, ... **camera systems** disposed within the industrial automation **system** .... The humans 26 may include any **person** that may be present in the .... **illumination** ... **light** ..... In one embodiment, a default **action** may be defined or determined ...
Overview · Related · Discuss

Lighting device for floors
www.google.com/patents/US20100052866



App. - Filed Nov 8, 2007 - Published Mar 4, 2010 - Reinhold Elferich - Koninklijke Philips Electronics N.V.
The invention relates to a **lighting** device, particularly a **lighting** tile (100, 100 ') for paving e.g. a floor area ... Moreover, it relates to a traffic control **system** comprising such a **lighting** device and to a method for ... **guided** ... **person**. The distance at which the **object** is detected as being "nearby" may depend on the .... **action** ...
Overview · Related · Discuss

Emergency lighting and evacuation guidance system powered by medley ...
www.google.com/patents/US9024774

Grant - Filed May 14, 2013 - Issued May 5, 2015 - Shaobin Li - Shenzhen Guangan Fire-Fighting & Decoration Engineering Co., Ltd.
Another **object** of the present invention is to provide an emergency **lighting** and evacuation guidance **system** powered by medley complementary energy sources ...
Overview · Related · Discuss

Amazon Ex. 1002.0412

Optoelectronic device, system and method for obtaining an ambient ...

www.google.com/patents/US9420666

Grant - Filed Jan 3, 2011 - Issued Aug 16, 2016 - Josep Maria Carreras Molins - Fundacio Institut De Recerca De L'energia De Catalunya

Also, a system for modifying the environmental **light** of an area is provided, the ... **lights** (being artificial, natural, or reflections of nearby **objects** or **people**) .... In this manner, the **light** entering into the waveguide can be **guided** towards the ... where individuals' **actions** are the primary inputs, and the **lighting system** ..... **camera** ...

Overview · Related · Discuss

Edge lighting system for interactive display surface

www.google.com/patents/US20060109199



App. - Filed Nov 24, 2004 - Published May 25, 2006 - Dawson Yee - Microsoft Corporation

An edge **lighting system** has a plurality of **light** sources, such as **light** emitting ... Any **object** approaching the display surface is illuminated by the **light** being conveyed within the material. ... This multiple **camera** mounting configuration is clearly not a compact system that most **people** would want to use in a residential setting.

Overview · Related · Discuss

Time-of-flight camera with guided light

www.google.com/patents/US9056254

Grant - Filed Oct 6, 2014 - Issued Jun 16, 2015 - Asaf Pellman - Microsoft Technology Licensing, Llc

A gaming system comprising a time-of-flight 3D **camera** and related method for ... To compensate for a decrease in irradiance with angular displacement of an **object** in a scene, a **camera illumination system** may be configured .... **person** ..... time perception of and response to the **actions** of an unencumbered participant/user.

Overview · Related · Discuss

Amazon EX. 1002.0413

The gesture pendant: A self-**illuminating**, wearable, infrared computer vision **system** for home automation control and medical monitoring

T Starner, J Auxier, D Ashbrook... - Digest of Papers. Fourth ..., 2000 - ieeexplore.ieee.org

... you might have to excuse yourself from the dinner conversation and then loudly state a phrase such as “computer, lower **lights** to level 2.” In ... IR **Light** ... We have demonstrated a wearable gesture recognition **system** that can be used in a variety of **lighting** conditions to control home ...

☆ 99 Cited by 374 Related articles All 27 versions »

Time-of-flight **cameras** in computer graphics

A Kolb, E Barth, R Koch, R Larsen - Computer Graphics Forum, 2010 - Wiley Online Library

... the amplitude value corresponds to the amount of incident active **light** and thus ... however, some manufacturers have already implemented more sophisticated active **illumination** units that ... and registering all scene geometry into a consistent reference coordinate **system** [[HJS08]] ...

☆ 99 Cited by 489 Related articles All 27 versions

Real-time omnidirectional image sensor (COPIS) for vision-**guided** navigation

Y Yagi, S Kawato, S Tsuji - IEEE Transactions on robotics and ..., 1994 - ieeexplore.ieee.org

... 161 proposed another real-time omnidirectional active sensing method using a conic mirror and sheets of **light** ... We represent the image and the space by two polar coordinate **systems** (T, 6') and (R, 6'. Z ... For example, no extra **lighting system** was used for the image shown in Fig ...

☆ 99 Cited by 325 Related articles All 7 versions

Multi-**camera** multi-**person** tracking for easyliving

J Krumm, S Harris, B Meyers, B Brumitt... - ... Workshop on Visual ..., 2000 - ieeexplore.ieee.org

... Invoking a particular user's preferences, such as **lighting** or audio ... Thus there are several histograms stored for each **person** in different parts of the room, reducing the effect of spatially varying **illumination** color and ... [9] RT Collins, AJ Lipton, and T. Kanade, “A **System** for Video ...

☆ 99 Cited by 992 Related articles All 16 versions »

Human activity recognition from 3d data: A review

JK Aggarwal, L Xia - Pattern Recognition Letters, 2014 - Elsevier

... a photometric stereo technique, which uses a fixed digital **camera** and three **lights** to **illuminate** ... Structured **light cameras** calculate the depth by projecting a structured **light** onto the scene and ... of the actor can be difficult when there is background clutter or bad **lighting** conditions ...

☆ 99 Cited by 311 Related articles All 5 versions

Bonfire: a nomadic **system** for hybrid laptop-tabletop interaction

SK Kane, D Avrahami, JO Wobbrock... - Proceedings of the ..., 2009 - dl.acm.org

... configuration, and adapts to gradual **lighting** changes over time, such as the changing **light** from a ... to provide **lightweight**, user-driven calibration steps (eg, hand-color training) ... and color schemes can help make Bonfire's projection visible even under difficult **lighting** conditions ...

☆ 99 Cited by 145 Related articles All 16 versions »

Augmented surfaces: a spatially continuous work space for hybrid computing environments

J Rekimoto, M Saitoh - ... on Human Factors in Computing Systems, 1999 - dl.acm.org

... VIDEODESiK[4] con- sists of a **light** table and a video **camera** ... Its application called Illuminat- ing **Lights**[191 helps a holography designer to rapidly layout physical optics devices on the desk ... **Illuminating Light**: An optical design tool with a luminous-tangible inter- face ...

☆ 99 Cited by 865 Related articles All 17 versions »

EYEWATCHME—3D hand and **object** tracking for inside out activity analysis

L Sun, U Klank, M Beetz - 2009 IEEE Computer Society ..., 2009 - ieeexplore.ieee.org

... On one hand, these recognition capabil- ities will enable activity recognition **systems** to better seg ... a transformed Y'Cb'Cr' color space which can reduce the effect of **lighting** condition to ... To this end, the **system** learns planar edge structures of the working environment beforehand ...

☆ 99 Cited by 48 Related articles All 6 versions

Amazon Ex. 1002.0414

RFID-**guided** robots for pervasive automation

T Deyle, H Nguyen, M Reynolds... - IEEE Pervasive ..., 2010 - ieeexplore.ieee.org

... Intelligent Robots and **Systems** (IROS 08), IEEE Press, 2008, pp ... state change when EL-E uses the **object** successfully, such as using the **camera** to detect overall brightness changes in **lighting** ... tells EL-E where to look to observe this state change, such as up for the **light** switches ...

☆ 99 Cited by 43 Related articles All 14 versions

Gaze **guided object** recognition using a head-mounted eye tracker

T Toyama, T Kieninger, F Shafait... - Proceedings of the ..., 2012 - dl.acm.org

... methods, recognition **systems** can be developed that have excel- lent robustness against **lighting** and position ... the runtime **system** as described in Section 1, ie with the same **illumination** and spatial ... table and all recordings and experiments were done under the same **light** setting ...

☆ 99 Cited by 69 Related articles All 7 versions »

Amazon Ex. 1002.0415

To: patents@gardner-linn.com,clark@gardner-linn.com,Vredeveld@gardner-linn.com
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/600,054	05/19/2017	Paul Ryznar	RYZ01 P-101B	6939

15671 7590 07/19/2019

Gardner, Linn, Burkhart & Ondersma LLP
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Grand Rapids, MI 49546

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EVERETT, CHRISTOPHER E

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Applicant-Initiated Interview Summary	**Application No.** 15/600,054	**Applicant(s)** Ryznar et al.	
	Examiner CHRISTOPHER E EVERETT	**Art Unit** 2116	**AIA (FITF) Status** No

All participants (applicant, applicants representative, PTO personnel):

(1) CHRISTOPHER E. EVERETT. (3) _____.

(2) Karl Ondersma, Reg. No. 55,894. (4) _____.

Date of Interview: 16 July 2019.

Type: ☑ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☐ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☑102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 1 and 3.

Identification of prior art discussed: U.S. Patent Publication No. 2005/0225753 (Engelbart).

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

See Continuation Sheet.

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/Christopher E. Everett/ Primary Examiner, Art Unit 2116	

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiners responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicants correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,-
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicants record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiners version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, Interview Record OK on the paper recording the substance of the interview along with the date and the examiners initials.

Continuation of Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments:

Applicant's representative, Karl Ondersma, and Examiner Christopher E. Everett discussed the technology within the patent application including the indicating light, visual indicator, and camera. Applicant's representative and Examiner discussed the difference between the prior art and the technology. In particular, Applicant's representative and Examiner discussed how the prior art was directed to a camera used to capture images of defects in a structure (Engelbart) and the technology utilizes a camera to image the visual indicator when projected onto the physical object. Applicant's representative and Examiner discussed claims 1 and 3 with respect to the overview of the technology and the cited prior art (Engelbart). No agreement was reached with respect to the claim rejections.

To: patents@gardner-linn.com,clark@gardner-linn.com,Vredeveld@gardner-linn.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 15671

Jul 19, 2019 03:36:39 AM

Dear PAIR Customer:

Gardner, Linn, Burkhart & Ondersma LLP
2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546
UNITED STATES

The following USPTO patent application(s) associated with your Customer Number, 15671 , have new outgoing correspondence. This correspondence is now available for viewing in Private PAIR.

The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

Disclaimer:
The list of documents shown below is provided as a courtesy and is not part of the official file wrapper. The content of the images shown in PAIR is the official record.

Application	Document	Mailroom Date	Attorney Docket No.
15600054	INTV.SUM.APP	07/19/2019	RYZ01 P-101B

To view your correspondence online or update your email addresses, please visit us anytime at https://sportal.uspto.gov/secure/myportal/privatepair.

If you have any questions, please email the Electronic Business Center (EBC) at EBC@uspto.gov with 'e-Office Action' on the subject line or call 1-866-217-9197 during the following hours:

Monday - Friday 6:00 a.m. to 12:00 a.m.

Thank you for prompt attention to this notice,

UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

Doc Code: A.NE.AFCP
Document Description: After Final Consideration Pilot Program Request

PTO/SB/434 (05-13)

CERTIFICATION AND REQUEST FOR CONSIDERATION UNDER THE AFTER FINAL CONSIDERATION PILOT PROGRAM 2.0

Practitioner Docket No.:	Application No.:	Filing Date:
RYZ01 P-101B	15/600,054	May 19, 2017
First Named Inventor:	**Title:**	
Paul Ryznar	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD	

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS CONSIDERATION UNDER THE AFTER FINAL CONSIDERATION PILOT PROGRAM 2.0 (AFCP 2.0) OF THE ACCOMPANYING RESPONSE UNDER 37 CFR 1.116.

1. The above-identified application is (i) an original utility, plant, or design nonprovisional application filed under 35 U.S.C. 111(a) [a continuing application (*e.g.*, a continuation or divisional application) is filed under 35 U.S.C. 111(a) and is eligible under (i)], or (ii) an international application that has entered the national stage in compliance with 35 U.S.C. 371(c).
2. The above-identified application contains an outstanding final rejection.
3. Submitted herewith is a response under 37 CFR 1.116 to the outstanding final rejection. The response includes an amendment to at least one independent claim, and the amendment does not broaden the scope of the independent claim in any aspect.
4. This certification and request for consideration under AFCP 2.0 is the only AFCP 2.0 certification and request filed in response to the outstanding final rejection.
5. Applicant is willing and available to participate in any interview requested by the examiner concerning the present response.
6. This certification and request is being filed electronically using the Office's electronic filing system (EFS-Web).
7. Any fees that would be necessary consistent with current practice concerning responses after final rejection under 37 CFR 1.116, *e.g.*, extension of time fees, are being concurrently filed herewith. [There is no additional fee required to request consideration under AFCP 2.0.]
8. By filing this certification and request, applicant acknowledges the following:
    - Reissue applications and reexamination proceedings are not eligible to participate in AFCP 2.0.
    - The examiner will verify that the AFCP 2.0 submission is compliant, *i.e.*, that the requirements of the program have been met (see items 1 to 7 above). For compliant submissions:
        - The examiner will review the response under 37 CFR 1.116 to determine if additional search and/or consideration (i) is necessitated by the amendment and (ii) could be completed within the time allotted under AFCP 2.0. If additional search and/or consideration is required but cannot be completed within the allotted time, the examiner will process the submission consistent with current practice concerning responses after final rejection under 37 CFR 1.116, *e.g.*, by mailing an advisory action.
        - If the examiner determines that the amendment does not necessitate additional search and/or consideration, or if the examiner determines that additional search and/or consideration is required and could be completed within the allotted time, then the examiner will consider whether the amendment places the application in condition for allowance (after completing the additional search and/or consideration, if required). If the examiner determines that the amendment does not place the application in condition for allowance, then the examiner will contact the applicant and request an interview.
            - The interview will be conducted by the examiner, and if the examiner does not have negotiation authority, a primary examiner and/or supervisory patent examiner will also participate.
            - If the applicant declines the interview, or if the interview cannot be scheduled within ten (10) calendar days from the date that the examiner first contacts the applicant, then the examiner will proceed consistent with current practice concerning responses after final rejection under 37 CFR 1.116.

Signature	Date
/Karl T. Ondersma/	August 20, 2019
Name (Print/Typed) Karl T. Ondersma	**Practitioner Registration No.** 55894

***Note**: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.*

[✓] * Total of 1 forms are submitted.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	36924879
Application Number:	15600054
International Application Number:	
Confirmation Number:	6939
Title of Invention:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Paul Ryznar
Customer Number:	15671
Filer:	Karl T. Ondersma/Leslie Vredeveld
Filer Authorized By:	Karl T. Ondersma
Attorney Docket Number:	RYZ01 P-101B
Receipt Date:	20-AUG-2019
Filing Date:	19-MAY-2017
Time Stamp:	14:03:27
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	After Final Consideration Program Request	01-AfterFinalPilotRequest.pdf	226734 bfddf99a02d6e12bc3c7389afad4fc2324b0301b	no	2

Warnings:

Information:					
2	Response After Final Action	02-ResponseB.pdf	31127 ab04dcad864eb841b42082b9b41fc80112f1d454	no	6
Warnings:					
Information:					
			Total Files Size (in bytes):	257861	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT
RYZ01 P101B

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Serial No.	: 15/600,054
Applicant	: OPS Solutions LLC
Filing Date	: May 19, 2017
Examiner	: Christopher E. Everett
Group	: 2116
For	: LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
Customer No.	: 15671
Confirmation No.	: 6939

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

RESPONSE

This is in response to the Final Office Action mailed May 20, 2019.

The Claims are reflected in the listing of claims, which begins on page 2 of this paper.

Remarks begin on page 5 of this paper.

Listing of the Claims:

This listing of claims will replace all prior versions and listings of the claims in the application:

1. (Cancelled)

2. (Cancelled)

3. (Currently Amended) A method of projecting visual indicators to guide actions of an individual for a particular guided operation, said method comprising:

projecting a visual indicator using a directional light device onto a physical object associated with the particular guided operation;

imaging the projected visual indicator with a camera located proximate to the directional light device;

transmitting images from the camera to a monitor located remotely from the directional light device; and

displaying images from the camera on the monitor.;

wherein said imaging, by the camera, captures images of at least the individual being guided, the physical object and the projected visual indicator.

4. (Cancelled)

5. (Previously Presented) The method of claim 3, further comprising receiving, by the guide system controller, a sequence of one or more input signals and prompting the directional light device to project the visual indicator for the particular guided operation.

6. (Previously Presented) The method of claim 5, wherein the sequence of one or more input signals are provided by a separate computer system or controller to the guide system controller.

7. (Previously Presented) The method of claim 3, further comprising receiving, by the guide

system controller, a sequence of input signals and prompting the directional light device to dynamically project a sequence of visual indicators onto the physical object for the particular guided operation based on the sequence of the input signals.

8. (Previously Presented) The method of claim 7, further comprising receiving, by the guide system controller, a combination of the sequence of the input signals and generation of a dynamic, real-time projection, via the directional light device, of the sequence of said visual indicators.

9. (Previously Presented) The method of claim 8, wherein the sequence of input signals are provided by a separate computer system or controller to the guide system controller.

10. (Currently Amended) A guide system adapted to provide visual indicators to an individual to guide actions of the individual for a particular guided operation, said guide system comprising:

a directional light device, said directional light device being selectively operable to project and target at least one indicating light;

a guide system controller, said guide system controller being operable to control said directional light device to project a visual indicator with said indicating light onto a physical object associated with the particular guided operation;

a camera located proximate to said directional light device and configured to capture an image of at least the individual, the physical object and said visual indicator when said visual indicator is projected onto the physical object;

a monitor, said monitor being remote from said directional light device and said guide system controller, with said monitor being operably interfaced with said camera to display the image captured by said camera.

11. (Previously Presented) The system of claim 10, wherein said guide system controller is configured to receive a sequence of one or more input signals causing said directional light device to project said visual indicator for the particular guided operation.

12. (Previously Presented) The system of claim 11, further including a separate computer system

or controller and wherein said separate computer system or controller is configured to provide the sequence of one or more input signals to said guide system controller.

13. (Previously Presented) The system of claim 10, wherein said guide system controller is configured to receive a sequence of input signals and to cause said directional light device to dynamically project a sequence of visual indicators onto the physical object for the particular guided operation based on the sequence of the input signals.

14. (Previously Presented) The system of claim 13, wherein a combination of the sequence of the input signals results in a generation of a dynamic, real-time projection of the sequence of said visual indicators.

15. (Previously Presented) The system of claim 14, further including a separate computer system or controller and wherein said separate computer system or controller is configured to provide the sequence of input signals to said guide system controller.

REMARKS

Applicant's undersigned representative thanks the Examiner for the courtesies extended during the telephonic discussion of July 16, 2019. The amendments and remarks presented herein are believed to be fully responsive to the Final Office Action dated May 20, 2019. Claims 3 and 5-15 are pending in the application, with claims 3 and 10 having been amended, and claims 1, 2 and 4 cancelled, as set forth above. The amendments are fully supported in the specification and drawings as originally filed. No new matter has been added.

The present response is being filed under AFCP 2.0. Applicant is willing and available to participate in any Examiner initiated interview concerning the present Response.

Allowable Claims

Claims 10-15 were indicated as being allowed.

Claim 4 was indicated as being allowable, but being dependent on a rejected base claim. Claim 3 has been amended to incorporate allowable claim 4 such that claim 3 is in condition for allowance.

Claim Rejections – 35 U.S.C. § 102

Claims 1 and 3 were rejected as being unpatentable over Engelbart (U.S. Patent Publication No. 2005/0225753).

Claim Rejections – 35 U.S.C. § 103

Claim 2 was rejected as being unpatentable over Engelbart (US 2005/0225753) in view of Wechter (US 2011/0178627).

Claim 5-6 were rejected under 35 U.S.C. §103(a) as being unpatentable over Engelbart (US 2005/0225753) in view of Ryznar (US 2008/0121168).

Claim 7-9 were rejected under 35 U.S.C. §103(a) as being unpatentable over Engelbart (US 2005/0225753) in view of Ryznar (US 2011/0178627) and further in view of Wechter (US 2011/0178627).

Applicant respectfully traverses the rejections under 35 U.S.C. §103(a). Notwithstanding, in order to expedite prosecution Applicant has amended claim 3 to incorporate allowable claim 4 such that claim 3 is in condition for allowance, along with claims 5-9 depending therefrom.

Applicant has also amended independent claim 10 to clarify that the guide system controller is operable to control the directional light device to project a visual indicator with the indicating light onto a physical object associated with the particular guided operation.

The Examiner is invited to contact Applicant's undersigned representative should there be any questions or suggestions.

Respectfully submitted,

OPS SOLUTIONS LLC

By: Gardner, Linn, Burkhart & Ondersma LLP

Date: August 20, 2019

/Karl T. Ondersma/
Karl T. Ondersma
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Grand Rapids, Michigan 49546
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KTO:lrv

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/600,054	Filing Date 05/19/2017	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $40 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $210 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	08/22/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 12	Minus	** 20	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $230 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/CURTIS NELLOMS JR/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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NOTICE OF ALLOWANCE AND FEE(S) DUE

15671 7590 09/05/2019

Gardner, Linn, Burkhart & Ondersma LLP
2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546

EXAMINER
EVERETT, CHRISTOPHER E

ART UNIT	PAPER NUMBER
2116	

DATE MAILED: 09/05/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/600,054	05/19/2017	Paul Ryznar	RYZ01 P-101B	6939

TITLE OF INVENTION: LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	12/05/2019

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

Amazon Ex. 1002.0433

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

15671 7590 09/05/2019

Gardner, Linn, Burkhart & Ondersma LLP
2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/600,054	05/19/2017	Paul Ryznar	RYZ01 P-101B	6939

TITLE OF INVENTION: LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	12/05/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
EVERETT, CHRISTOPHER E	2116	700-095000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

Amazon Ex. 1002.0434

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/600,054	05/19/2017	Paul Ryznar	RYZ01 P-101B	6939

15671 7590 09/05/2019

Gardner, Linn, Burkhart & Ondersma LLP
2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546

EXAMINER	
EVERETT, CHRISTOPHER E	
ART UNIT	PAPER NUMBER
2116	

DATE MAILED: 09/05/2019

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Amazon Ex. 1002.0435

Notice Requiring Inventor's Oath or Declaration	Application No. 15/600,054	Applicant(s) Paul Ryznar	
	Examiner EVERETT, CHRISTOPHER E	Art Unit 2116	

This notice is an attachment to the Notice of Allowability (PTOL-37), or the Notice of Allowability For A Design Application (PTOL-37D).

An inventor's oath or declaration in compliance with 37 CFR 1.63 or 1.64 executed by or with respect to each inventor has not yet been submitted.

An oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each inventor (for any inventor for which a compliant oath, declaration, or substitute statement has not yet been submitted) MUST be filed no later than the date on which the issue fee is paid. See 35 U.S.C. 115(f). Failure to timely comply will result in ABANDONMENT of this application.

A properly executed inventor's oath to declaration has not been received for the following inventor(s):

If applicant previously filed one or more oaths, declarations, or substitute statements, applicant may have received an informational notice regarding deficiencies therein.

The following deficiencies are noted:

INFORMAL ACTION PROBLEMS

A new inventor's oath or declaration that identifies this application (e.g., by Application Number and filing date) is required. The inventor's oath or declaration does not comply with 37 CFR 1.63 in that it:

- does not state that the above-identified application was made or authorized to be made by the person executing the oath or declaration: **Paul Ryznar** and **James Ryznar**.

Questions relating to this Notice should be directed to the Application Assistance Unit at 571-272-4200.

Amazon Ex. 1002.0436

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Amazon Ex. 1002.0437

Notice of Allowability	Application No. 15/600,054	Applicant(s) Ryznar et al.	
	Examiner CHRISTOPHER E EVERETT	Art Unit 2116	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 8/20/2019.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 3 and 5-15 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☑ Other PTO-2323 After-Final Consideration Pilot.

/Christopher E. Everett/
Primary Examiner, Art Unit 2116

DETAILED ACTION

1. The Office Action is responsive to the communication filed on 8/20/2019.

2. Claims 3 and 5-15 are pending.

Notice of Pre-AIA or AIA Status

3. The present application is being examined under the pre-AIA first to invent provisions.

Allowable Subject Matter

4. Claims 3 and 5-15 are allowed.

5. The following is an examiner's statement of reasons for allowance:

Claims 3 and 5-9

Regarding claim 3, the prior art as described in the prosecution history describes:

A method of projecting visual indicators to guide actions of an individual for a particular guided operation, said method comprising:

- projecting a visual indicator using a directional light device onto a physical object associated with the particular guided operation;

However, regarding claim 3, the prior art as described in the prosecution history does not describe:

- imaging the projected visual indicator with a camera located proximate to the directional light device;
- transmitting images from the camera to a monitor located remotely from the directional light device; and
- displaying images from the camera on the monitor;
- wherein said imaging, by the camera, captures images of at least the individual being guided, the physical object and the projected visual indicator.

Dependent claims 5-9 depend from independent claim 3 and are allowable for the same reasons as described above.

Claims 10-15

Independent claim 10 is substantially similar to independent claim 3 and is allowable for the same reasons as outlined above with respect to claim 3. Dependent claims 11-15 depend from independent claim 10 and are allowable for the same reasons as described above.

6. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to CHRISTOPHER E EVERETT whose telephone number is (571)272-2851. The examiner can normally be reached on Monday-Friday 8:00 am to 5:00 pm (Eastern).

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kenneth Lo can be reached on 571-272-9774. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Christopher E. Everett/
Primary Examiner, Art Unit 2116

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	Art Unit
	CHRISTOPHER E EVERETT	2116

CPC - Searched*		
Symbol	**Date**	**Examiner**
(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001)	11/15/2018	CEE

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
Search of DAV using inventors	11/15/2018	CEE
Search of EAST using inventors, assignee, and text searches	11/16/2018	CEE
Search of (G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001) using text searches	11/16/2018	CEE
Search of 700/95 using text searches	11/16/2018	CEE
Review of file history and references from parent application no. 13/98444	11/15/2018	CEE
Update of EAST and sub-class searches as described above	05/15/2019	CEE
Search of Google patent using text searches	05/15/2019	CEE
Search of Google scholar using text searches	05/15/2019	CEE
Update of EAST and sub-class searches as described above	08/28/2019	CEE

/Christopher E. Everett/ Primary Examiner, Art Unit 2116	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	Art Unit
	CHRISTOPHER E EVERETT	2116

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	Search of USPAT and USPGPUB using text searches	08/28/2019	CEE

/Christopher E. Everett/ Primary Examiner, Art Unit 2116	

Amazon Ex. 1002.0444

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	**Art Unit**
	CHRISTOPHER E EVERETT	2116

CPC						
Symbol					**Type**	**Version**
G05B	/	19	/	418	F	2013-01-01
G05B	/	19	/	41805	I	2013-01-01
G05B	/	2219	/	31027	A	2013-01-01
G05B	/	2219	/	31046	A	2013-01-01
G05B	/	2219	/	32001	A	2013-01-01
G05B	/	2219	/	35494	A	2013-01-01
Y02P	/	90	/	04	A	2015-11-01

CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	12	
/Christopher E. Everett/ Primary Examiner, Art Unit 2116	28 August 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	6

U.S. Patent and Trademark Office

Part of Paper No.: 20190828

Amazon Ex. 1002.0445

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	**Art Unit**
	CHRISTOPHER E EVERETT	2116

INTERNATIONAL CLASSIFICATION				
CLAIMED				
G05B19/418	/	19	/	418

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	12	
/Christopher E. Everett/ Primary Examiner, Art Unit 2116	28 August 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	6

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/600,054	Ryznar et al.
	Examiner	**Art Unit**
	CHRISTOPHER E EVERETT	2116

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	12	
/Christopher E. Everett/ Primary Examiner, Art Unit 2116	28 August 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	6

U.S. Patent and Trademark Office

Part of Paper No.: 20190828

Amazon Ex. 1002.0447

AFCP 2.0 Decision

Application No.	Applicant(s)	
15/600,054	Ryznar et al.	
Examiner	**Art Unit**	**AIA (FITF) Status**
CHRISTOPHER E EVERETT	2116	No

This is in response to the After Final Consideration Pilot request filed 20 August 2019.

1. **Improper Request** – The AFCP 2.0 request is improper for the following reason(s) and the after final amendment submitted with the request will be treated under pre-pilot procedure.

   ☐ An AFCP 2.0 request form PTO/SB/434 (or equivalent document) was not submitted.

   ☐ A non-broadening amendment to at least one independent claim was not submitted.

   ☐ The request is not the first proper AFCP 2.0 request submitted in response to the most recent final rejection.

   ☐ Other: _____

2. **Proper Request**

   A. After final amendment submitted with the request will not be treated under AFCP 2.0.
   The after final amendment cannot be reviewed and a search conducted within the guidelines of the pilot program.

   ☐ The after final amendment will be treated under pre-pilot procedure.

   B. Updated search and/or completed additional consideration.
   The examiner performed an updated search and/or completed additional consideration of the after final amendment within the time authorized for the pilot program. The result(s) of the updated search and/or completed additional consideration are:

   ☑ 1. All of the rejections in the most recent final Office action are overcome and a Notice of Allowance is issued herewith.

   ☐ 2. The after final amendment would not overcome all of the rejections in the most recent final Office action . See attached interview summary for further details.

   ☐ 3. The after final amendment was reviewed, and it raises a new issue(s). See attached interview summary for further details.

   ☐ 4. The after final amendment raises new issues, but would overcome all of the rejections in the most recent final Office action. A decision on determining allowability could not be made within the guidelines of the pilot. See attached interview summary for further details, including any newly discovered prior art.

   ☐ 5. Other: _____

   Examiner Note: Please attach an interview summary when necessary as described above.

Listing of the Claims:

This listing of claims will replace all prior versions and listings of the claims in the application:

1. (Cancelled)

2. (Cancelled)

3. (Currently Amended) A method of projecting visual indicators to guide actions of an individual for a particular guided operation, said method comprising:

projecting a visual indicator using a directional light device onto a physical object associated with the particular guided operation;

imaging the projected visual indicator with a camera located proximate to the directional light device;

transmitting images from the camera to a monitor located remotely from the directional light device; and

displaying images from the camera on the monitor~~.~~;

wherein said imaging, by the camera, captures images of at least the individual being guided, the physical object and the projected visual indicator.

4. (Cancelled)

5. (Previously Presented) The method of claim 3, further comprising receiving, by the guide system controller, a sequence of one or more input signals and prompting the directional light device to project the visual indicator for the particular guided operation.

6. (Previously Presented) The method of claim 5, wherein the sequence of one or more input signals are provided by a separate computer system or controller to the guide system controller.

7. (Previously Presented) The method of claim 3, further comprising receiving, by the guide

system controller, a sequence of input signals and prompting the directional light device to dynamically project a sequence of visual indicators onto the physical object for the particular guided operation based on the sequence of the input signals.

8. (Previously Presented) The method of claim 7, further comprising receiving, by the guide system controller, a combination of the sequence of the input signals and generation of a dynamic, real-time projection, via the directional light device, of the sequence of said visual indicators.

9. (Previously Presented) The method of claim 8, wherein the sequence of input signals are provided by a separate computer system or controller to the guide system controller.

10. (Currently Amended) A guide system adapted to provide visual indicators to an individual to guide actions of the individual for a particular guided operation, said guide system comprising:

a directional light device, said directional light device being selectively operable to project and target at least one indicating light;

a guide system controller, said guide system controller being operable to control said directional light device to project a visual indicator with said indicating light onto a physical object associated with the particular guided operation;

a camera located proximate to said directional light device and configured to capture an image of at least the individual, the physical object and said visual indicator when said visual indicator is projected onto the physical object;

a monitor, said monitor being remote from said directional light device and said guide system controller, with said monitor being operably interfaced with said camera to display the image captured by said camera.

11. (Previously Presented) The system of claim 10, wherein said guide system controller is configured to receive a sequence of one or more input signals causing said directional light device to project said visual indicator for the particular guided operation.

12. (Previously Presented) The system of claim 11, further including a separate computer system

or controller and wherein said separate computer system or controller is configured to provide the sequence of one or more input signals to said guide system controller.

13. (Previously Presented) The system of claim 10, wherein said guide system controller is configured to receive a sequence of input signals and to cause said directional light device to dynamically project a sequence of visual indicators onto the physical object for the particular guided operation based on the sequence of the input signals.

14. (Previously Presented) The system of claim 13, wherein a combination of the sequence of the input signals results in a generation of a dynamic, real-time projection of the sequence of said visual indicators.

15. (Previously Presented) The system of claim 14, further including a separate computer system or controller and wherein said separate computer system or controller is configured to provide the sequence of input signals to said guide system controller.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L6	8	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/08/28 09:49
L7	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/08/28 09:49
L8	6	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L9	8128	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L10	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L11	75742	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L12	105105	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L13	9148	L9 L10	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L14	63	L11 and L13	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L15	85	L12 and L13	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L16	142	L14 L15	US-	OR	ON	2019/08/28

			PGPUB; USPAT; FPRS; EPO			09:49
L17	664537	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L18	18949	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L19	255652	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L20	18	L18 and L13	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L21	19017	L17 and L19	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L22	626	L21 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L23	49	L22 and L13	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L24	181	L6 L7 L8 L14 L15 L16 L20 L23	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/08/28 09:49
L25	181	L24	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/08/28 09:49
S1	20	("4469553" | "20060106483" | "20070180674" | "5341183" | "6317980" | "7193696" | "7433796" | "7463368" | "20040111901" | "20060059699" | "20060185181" | "2682117" | "3600785" | "3623066" | "3667104" | "3986244" | "4102568" | "4163309" | "4222036" | "7515981").PN.	US-PGPUB; USPAT	OR	ON	2016/04/25 12:38
S2	1	("20080121168").PN.	US-	OR	OFF	2016/04/25

			PGPUB; USPAT; FPRS; EPO			12:40
S3	3	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/04/25 12:41
S4	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/04/25 12:41
S5	1	("2013/0325155").URPN.	USPAT	OR	ON	2016/04/25 12:41
S6	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S7	4	S4 S5	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S8	3	S2 S4	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S9	3	S3 S4	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:03
S10	4814	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:57
S11	1106	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 13:57
S12	56653	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S13	72690	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S14	5833	S10 S11	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00

S15	572	S12 and S13	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S16	47	S12 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S17	52	S13 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S18	96	S16 S17	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:00
S19	464998	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S20	47163	guide adj3 system	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S21	127	S12 and S13 and S19	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:02
S22	12930	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S23	190143	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S24	12	S22 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S25	12988	S19 and S23	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:03
S26	617	S25 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:04

S27	48	S26 and S14	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/04/25 14:04
S28	2	("7515981").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/12 11:43
S29	28	("20030073541" | "2682117" | "3600785" | "3623066" | "3667104" | "3986244" | "4102568" | "4163309" | "4222036" | "4318222" | "4469553" | "4890382" | "5119536" | "5430662" | "5506641" | "5801946" | "5910894" | "6224385" | "6658218" | "7027886").PN. OR ("7515981").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:43
S30	10	("20050128437" | "20110179624" | "20110243380" | "20110314001" | "6600476" | "7515981" | "7530019" | "8027745" | "8162486" | "8199108").PN. OR ("9412053").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:45
S31	20	("20030163219" | "20040225390" | "20050058969" | "20060085088" | "4961148" | "5771043" | "6188402" | "6345207" | "6453209" | "6477437" | "6725184" | "6788987" | "6819965").PN. OR ("8027745").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/12 11:56
S32	1	("20110178627").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/12 13:53
S33	4	("7307542").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/15 10:00
S34	2	("5406176").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	OFF	2016/08/15 10:06
S35	4	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/15 15:39
S36	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2016/08/15 15:39
S37	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S38	4683	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494	US-PGPUB; USPAT;	OR	ON	2016/08/15 15:39

		or G05B2219/32001).cpc.	FPRS; EPO			
S39	1106	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S40	57264	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S41	74554	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S42	5702	S38 S39	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S43	48	S40 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S44	53	S41 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S45	98	S43 S44	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S46	478537	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S47	12652	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S48	193361	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S49	11	S47 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S50	13487	S46 and S48	US-PGPUB; USPAT;	OR	ON	2016/08/15 15:39

			FPRS; EPO			
S51	625	S50 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S52	50	S51 and S42	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S53	136	S35 S36 S37 S43 S44 S45 S49 S52	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2016/08/15 15:39
S54	14	("6000801" | "6036319" | "6170163" | "6600476" | "7268893").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:21
S55	4	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/01/06 14:22
S56	3	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2017/01/06 14:22
S57	4	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S58	5375	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S59	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S60	60369	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S61	78761	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S62	6395	S58 S59	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22

S63	50	S60 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S64	54	S61 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S65	101	S63 S64	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S66	504181	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S67	14080	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S68	202896	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S69	12	S67 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S70	14194	S66 and S68	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S71	625	S70 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S72	50	S71 and S62	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S73	139	S55 S56 S57 S63 S64 S65 S69 S72	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22
S74	139	S73	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2017/01/06 14:22

S77	7	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 11:29
S78	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 11:29
S79	6	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S80	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S81	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S82	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S83	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S84	8083	S80 S81	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S85	57	S82 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S86	76	S83 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S87	127	S85 S86	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S88	613807	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S89	17531	(guide adj3 system).ab.	US-	OR	ON	2018/11/15

			PGPUB; USPAT; FPRS; EPO			11:29
S90	238507	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S91	15	S89 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S92	17380	S88 and S90	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S93	626	S92 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S94	49	S93 and S84	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S95	165	S77 S78 S79 S85 S86 S87 S91 S94	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S96	165	S95	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S97	165	S96	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:29
S98	72	("20040111901" | "20050154431" | "20060059699" | "20060106483" | "20060185181" | "20070180674" | "20110178627" | "2682117" | "3600785" | "3623066" | "3667104" | "3986244" | "4102568" | "4163309" | "4222036" | "4469553" | "5341183" | "5406176" | "6000801" | "6036319" | "6170163" | "6317980" | "6600476" | "7193696" | "7268893" | "7433796" | "7463368" | "7515981").PN.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 11:31
S99	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-	US-PGPUB; USPAT	OR	ON	2018/11/15 11:31

		20110178627-$ or US-20050154431-$).did. or (US-7515981-$ or US-7463368-$ or US-7193696-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.				
S100	9	S99 and camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 11:31
S101	1	("20050225753").PN.	US-PGPUB; USPAT	OR	OFF	2018/11/15 12:22
S102	3	((("OPS") near3 ("SOLUTIONS") near3 ("LLC"))).AS,AANM.	USPAT	OR	ON	2018/11/15 13:11
S103	8	((("RYZNAR") near3 ("Paul")) OR (("RYZNAR") near3 ("James"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2018/11/15 13:12
S104	8	S102 S103	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:12
S105	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-20110178627-$ or US-20050154431-$ or US-20050225753-$).did. or (US-7515981-$ or US-7463368-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.	US-PGPUB; USPAT	OR	ON	2018/11/15 13:29
S106	9	S105 and camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:29
S107	30	S105 and (camera image position)	US-	OR	ON	2018/11/15

			PGPUB; USPAT; FPRS; EPO; DERWENT			13:31
S108	31	(US-20060185181-$ or US-20070180674-$ or US-20060106483-$ or US-20060059699-$ or US-20040111901-$ or US-20080121168-$ or US-20130325155-$ or US-20110178627-$ or US-20050154431-$ or US-20050225753-$).did. or (US-7515981-$ or US-7463368-$ or US-6317980-$ or US-2682117-$ or US-3600785-$ or US-3623066-$ or US-3667104-$ or US-3986244-$ or US-4163309-$ or US-4102568-$ or US-4222036-$ or US-4469553-$ or US-5341183-$ or US-8027745-$ or US-7307542-$ or US-5406176-$ or US-7268893-$ or US-6600476-$ or US-6170163-$ or US-6036319-$ or US-6000801-$).did.	US-PGPUB; USPAT	OR	ON	2018/11/15 13:35
S109	30	S108 and (camera position image)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:35
S110	19	S109 and guide	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:37
S111	1	S108 and (camera adj4 guide)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:38
S112	23	S108 and (camera guide)	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/15 13:38
S113	111	S96 and guide	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:41
S114	576917	(camera).ab.clm.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:58
S115	709872	(camera).ab,clm.	US-PGPUB; USPAT; FPRS;	OR	ON	2018/11/15 13:58

			EPO			
S116	229216	(camera).clm.ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:59
S117	709879	S114 S116	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 13:59
S118	7	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 16:36
S119	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/11/15 16:36
S120	6	(ops adj2 solutions).as.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S121	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S122	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S123	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S124	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S125	8083	S121 S122	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S126	57	S123 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S127	76	S124 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36

S128	127	S126 S127	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S129	613807	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S130	17531	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S131	238507	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S132	15	S130 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S133	17380	S129 and S131	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S134	626	S133 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S135	49	S134 and S125	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S136	165	S118 S119 S120 S126 S127 S128 S132 S135	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S137	165	S136	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S138	165	S137	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/15 16:36
S139	165	S138	US-PGPUB; USPAT; FPRS; EPO;	OR	ON	2018/11/15 16:36

			DERWENT			
S140	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 12:10
S141	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 12:10
S142	8083	S140 S141	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 12:10
S143	23130	((directional visual) with (light guide)) same camera	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S144	8928	(((directional visual) with (light guide)) same camera).ab,clm,bsum.	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S145	7063	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
S146	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
S147	8083	S145 S146	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S148	71038	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
S149	111	S148 and S144	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S150	302	S148 and S143	US-PGPUB; USPAT; FPRS;	OR	ON	2018/11/16 13:38

			EPO; DERWENT			
S151	10	S143 and S147	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S152	6	S144 and S147	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S153	96339	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2018/11/16 13:38
S154	1393	S153 and S143	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S155	362	S153 and S144	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:38
S156	785	S153 and S148	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
S157	6	S147 and S156	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
S158	13	S151 S152 S157	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2018/11/16 13:39
S159	14	("7241981" | "7292269" | "7306339" | "8751049").PN.	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/14 14:31
S160	1	("7576727").PN.	US-PGPUB; USPAT	OR	OFF	2019/05/15 09:22
S161	445	("20010012001" | "20020041327" | "20020064382" | "20020103617" |	US-PGPUB;	OR	ON	2019/05/15 09:22

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S162	74029	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:24
S163	3	S161 and S162	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:24
S164	101714	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:24
S165	92	S161 and S164	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:24
S166	644661	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:24
S167	277	S161 and S166	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:24
S168	8	(("RYZNAR") near3 ("Paul")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/05/15 09:25
S169	5	(("RYZNAR") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/05/15 09:25
S170	6	(ops adj2 solutions).as.	US-PGPUB; USPAT;	OR	ON	2019/05/15 09:25

			FPRS; EPO			
S171	7722	(G05B19/418 or G05B19/41805 or Y02P90/04 or G05B2219/31046 or G05B2219/31027 or G05B2219/35494 or G05B2219/32001).cpc.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S172	1108	700/95.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S173	74029	(guide adj2 (system control controller))	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S174	101714	(project projector) adj5 (object work piece device)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S175	8742	S171 S172	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S176	60	S173 and S175	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S177	79	S174 and S175	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S178	133	S176 S177	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S179	644661	(guide visual indicator light projection) near4 (operator user)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S180	18477	(guide adj3 system).ab.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S181	249079	(pick place picking placing placement) adj4 (part component bin)	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S182	15	S180 and S175	US-PGPUB; USPAT;	OR	ON	2019/05/15 09:25

			FPRS; EPO			
S183	18351	S179 and S181	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S184	626	S183 and 700/$.ccls.	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S185	49	S184 and S175	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S186	172	S168 S169 S170 S176 S177 S178 S182 S185	US-PGPUB; USPAT; FPRS; EPO	OR	ON	2019/05/15 09:25
S187	172	S186	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:25
S188	94	S163 S165	US-PGPUB; USPAT; FPRS; EPO; DERWENT	OR	ON	2019/05/15 09:25
S189	350	("1402608" | "20010035845" | "20010044858" | "20010048429" | "20020158873" | "20030020707" | "20030034976" | "20030042401" | "20030071784" | "20030227470" | "20040037450" | "20040046711" | "20040046736" | "20040102247" | "20040125044" | "20040196282" | "20040257540" | "20050135670" | "20050185150" | "20050254726" | "20060001645" | "20060001650" | "20060036944" | "20060109239" | "20060158452" | "20060268363" | "20060294247" | "20070013716" | "20070055782" | "20070124370" | "20070126864" | "20070126938" | "20070132733" | "20070247422" | "20070285419" | "20070299338" | "20080002262" | "20080007567" | "20080024594" | "20080026838" | "20080031327" | "20080095468" | "20080143969" | "20080180402" | "20080199071" | "20080214233" | "20080229194" | "20080231634" | "20080239109" | "20080239250" | "20080246781" | "20080263458" | "20080285843" | "20080316201" | "20090027330" | "20090037841" |	US-PGPUB; USPAT; USOCR	OR	ON	2019/05/15 09:29

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EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	0	(imaging the projected visual indicator with a camera located proximate to the directional light device transmitting images from the camera to a monitor located remotely from the directional light device displaying images from the camera on the monitor wherein said imaging, by the camera captures images of at least the individual being guided the physical object and the projected visual indicator).clm.	US-PGPUB; USPAT	AND	ON	2019/08/28 09:48

L2	0	(wherein said imaging by the camera captures images of at least the individual being guided the physical object and the projected visual indicator).clm.	US-PGPUB; USPAT	AND	ON	2019/08/28 09:49
L3	0	(selecting one more particular addressed display features by said guide system controller from the plurality of said addressed display features based on said input signals wherein said input signals control selection of said addressed display features based on the address identifier for the said addressed display feature projecting one more visual indicators corresponding to said selected particular addressed display features onto one more physical objects associated with the particular guided operation with said guide system controller configured to control operation of said projector to project said visual indicators based on said input signals wherein said guide system controller is operative to receive any sequence of input signals from the separate computer system controller to dynamically control projection of any sequence of said visual indicators corresponding to respective said addressed display features based on said input signals corresponding to desired visual indicators for the particular operation with a combination of the sequence of input signals resulting in a creation of a dynamic real time projection of visual indicators).clm.	US-PGPUB; USPAT	AND	ON	2019/08/28 09:49
L4	0	(selecting one more particular addressed display features by said guide system controller from the plurality of said addressed display features based on said input signals wherein said input signals control selection of said addressed display features based on the address identifier for the said addressed display feature projecting one more visual indicators corresponding to said selected particular addressed display features onto one more physical objects associated with the particular guided operation with said guide system controller configured to control operation of said projector to project said visual indicators based on said input signals wherein said guide system controller is operative).clm.	US-PGPUB; USPAT	AND	ON	2019/08/28 09:49
L5	0	L3 L4	US-PGPUB; USPAT	AND	ON	2019/08/28 09:49
S75	0	(selecting one more particular addressed display features by said guide system controller from the plurality of said addressed display features based on said input signals wherein said input signals control selection of said addressed display features based on the address identifier for the said addressed display feature projecting one more visual indicators corresponding to said selected particular addressed display features onto one more physical objects associated with the particular guided operation with said guide system controller configured to control operation of said projector to project said visual indicators	US-PGPUB; USPAT	AND	ON	2017/01/06 14:30

		based on said input signals wherein said guide system controller is operative to receive any sequence of input signals from the separate computer system controller to dynamically control projection of any sequence of said visual indicators corresponding to respective said addressed display features based on said input signals corresponding to desired visual indicators for the particular operation with a combination of the sequence of input signals resulting in a creation of a dynamic real time projection of visual indicators).clm.				
S76	0	(selecting one more particular addressed display features by said guide system controller from the plurality of said addressed display features based on said input signals wherein said input signals control selection of said addressed display features based on the address identifier for the said addressed display feature projecting one more visual indicators corresponding to said selected particular addressed display features onto one more physical objects associated with the particular guided operation with said guide system controller configured to control operation of said projector to project said visual indicators based on said input signals wherein said guide system controller is operative).clm.	US-PGPUB; USPAT	AND	ON	2017/01/06 14:30

8/ 28/ 2019 9:53:46 AM
C:\ Users\ ceverett\ Documents\ EAST\ Workspaces\ 15600054-LightGuidedOperation.wsp

Bibliographic Data

Application No: 15/600,054

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /Christopher E. Everett/ Examiner's Signature | Initials

Title: LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
05/19/2017	700	2116	RYZ01 P-101B
RULE			

APPLICANTS

OPS Solutions LLC, Wixom, MI, UNITED STATES

INVENTORS

Paul Ryznar Northville, MI, UNITED STATES

James Ryznar Belleville, MI, UNITED STATES

CONTINUING DATA

This application is a CON of 13984744 08/09/2013 PAT 9658614

13984744 is a 371 of PCT/US2012/024730 02/10/2012

PCT/US2012/024730 has PRO of 61441897 02/11/2011

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

05/25/2017

**** SMALL ENTITY ****

STATE OR COUNTRY

UNITED STATES

ADDRESS

Gardner, Linn, Burkhart & Ondersma LLP

2900 Charlevoix Dr., SE, Suite 300

Grand Rapids, MI 49546

UNITED STATES

FILING FEE RECEIVED

$730

To: patents@gardner-linn.com,clark@gardner-linn.com,Vredeveld@gardner-linn.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 15671

Sep 05, 2019 03:37:12 AM

Dear PAIR Customer:

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2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546
UNITED STATES

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Application	Document	Mailroom Date	Attorney Docket No.
15600054	NOA	09/05/2019	RYZ01 P-101B
	A.NE.AFCP.D	09/05/2019	RYZ01 P-101B

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PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

15671 7590 09/05/2019
Gardner, Linn, Burkhart & Ondersma LLP
2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

Leslie R. Vredeveld	(Typed or printed name)
/Leslie R. Vredeveld/	(Signature)
December 2, 2019	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/600,054	05/19/2017	Paul Ryznar	RYZ01 P-101B	6939

TITLE OF INVENTION: LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	12/05/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
EVERETT, CHRISTOPHER E	2116	700-095000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 Gardner, Linn, Burkhart &
3 Ondersma LLP

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: OPS Solutions LLC

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Wixom, Michigan (US)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 505553

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Karl T. Ondersma/ Date December 2, 2019

Typed or printed name Karl T. Ondersma Registration No. 55894

Amazon Ex. 1002.0477

Electronic Patent Application Fee Transmittal

Application Number:	15600054
Filing Date:	19-May-2017
Title of Invention:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Paul Ryznar
Filer:	Karl T. Ondersma/Leslie Vredeveld
Attorney Docket Number:	RYZ01 P-101B

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	500	500

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**500**

Electronic Acknowledgement Receipt

EFS ID:	37902878
Application Number:	15600054
International Application Number:	
Confirmation Number:	6939
Title of Invention:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Paul Ryznar
Customer Number:	15671
Filer:	Karl T. Ondersma/Leslie Vredeveld
Filer Authorized By:	Karl T. Ondersma
Attorney Docket Number:	RYZ01 P-101B
Receipt Date:	02-DEC-2019
Filing Date:	19-MAY-2017
Time Stamp:	17:15:02
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$500
RAM confirmation Number	E2019B2H15514762
Deposit Account	505553
Authorized User	Leslie Vredeveld

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.20 (Post Issuance fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	PTO-85.pdf	96776 012656f2771ecdd4a540156886914ae9c891db8b	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	29998 a5863e6fe5b8d91a8c85c252e0fe7e897c2b119b	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	126774		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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PATENT
RYZ01 P-101B

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Confirmation No.	:	6939
Applicant	:	OPS Solutions LLC
Serial No.	:	15/600,054
Filing Date	:	May 19, 2017
For	:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

SUBMITTAL OF NEW DECLARATIONS

Receipt of Notice Requiring Inventor's Oath or Declaration, sent with the Notice of Allowance on September 5, 2019, noting that the application was filed with declarations that did not comply with 37 CFR 1.63 in that the declarations filed with the applications did not state that the application was made or authorized to be made by the person executing the declaration. The Notice therefore required new declarations to be filed that identified the application.

Accordingly, Applicant herewith files new Declaration documents in accordance with 37 CFR 1.63 duly executed by the inventors.

Please charge any required fees to Deposit Account No. 50 5553.

Respectfully submitted,

OPS SOLUTIONS LLC

By: Gardner, Linn, Burkhart & Ondersma LLP

Dated: December 2, 2019

/Karl T. Ondersma/
Karl T. Ondersma
Registration No. 55 894
2900 Charlevoix Drive, S.E., Suite 300
Grand Rapids, Michigan 49546
(616) 975-5500

KTO:lrv

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number 15/600,054 filed on May 19, 2017.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: James Ryznar Date (Optional): 11-29-19

Signature: [signature]

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number 15/600,054 filed on May 19, 2017.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: Paul Ryznar Date (Optional) :

Signature: Paul Ryznar

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Electronic Acknowledgement Receipt

EFS ID:	37902609
Application Number:	15600054
International Application Number:	
Confirmation Number:	6939
Title of Invention:	LIGHT GUIDED ASSEMBLY SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Paul Ryznar
Customer Number:	15671
Filer:	Karl T. Ondersma/Leslie Vredeveld
Filer Authorized By:	Karl T. Ondersma
Attorney Docket Number:	RYZ01 P-101B
Receipt Date:	02-DEC-2019
Filing Date:	19-MAY-2017
Time Stamp:	17:11:11
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	01-Transmittal.pdf	14021 a6fb3e9883ed01cdb3c3c111d00b949334589035	no	1

Warnings:

Information:					
2	Oath or Declaration filed	02-Declarations.pdf	391057 544d636ffd6fe791e3d8260062c0886c71eb1131	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	405078		

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National Stage of an International Application under 35 U.S.C. 371

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New International Application Filed with the USPTO as a Receiving Office

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/600,054	01/07/2020	10528036	RYZ01 P-101B	6939

15671 7590 12/18/2019

Gardner, Linn, Burkhart & Ondersma LLP
2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 70 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Paul Ryznar, Northville, MI;
OPS Solutions LLC, Wixom, MI;
James Ryznar, Belleville, MI;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

Amazon Ex. 1002.0487

To: patents@gardner-linn.com,clark@gardner-linn.com,Vredeveld@gardner-linn.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 15671

Dec 19, 2019 03:37:21 AM

Dear PAIR Customer:

Gardner, Linn, Burkhart & Ondersma LLP
2900 Charlevoix Dr., SE, Suite 300
Grand Rapids, MI 49546
UNITED STATES

The following USPTO patent application(s) associated with your Customer Number, 15671 , have new outgoing correspondence. This correspondence is now available for viewing in Private PAIR.

The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

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Application	Document	Mailroom Date	Attorney Docket No.
15600054	ISSUE.NTF	12/18/2019	RYZ01 P-101B

To view your correspondence online or update your email addresses, please visit us anytime at https://sportal.uspto.gov/secure/myportal/privatepair.

If you have any questions, please email the Electronic Business Center (EBC) at EBC@uspto.gov with 'e-Office Action' on the subject line or call 1-866-217-9197 during the following hours:

Monday - Friday 6:00 a.m. to 12:00 a.m.

Thank you for prompt attention to this notice,

UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT7273007

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	CONVERSION AND CHANGE OF NAME

CONVEYING PARTY DATA

Name	Execution Date
OPS SOLUTIONS LLC	06/29/2021

RECEIVING PARTY DATA

Name:	LIGHTGUIDE, INC.
Street Address:	48443 ALPHA DRIVE
Internal Address:	SUITE 175
City:	WIXOM
State/Country:	MICHIGAN
Postal Code:	48393

PROPERTY NUMBERS Total: 7

Property Type	Number
Patent Number:	7515981
Patent Number:	9658614
Patent Number:	9965897
Patent Number:	10528036
Patent Number:	10983500
Application Number:	17235556
Application Number:	17432778

CORRESPONDENCE DATA

Fax Number: (616)975-5505

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 616-975-5500
Email: vredeveld@gardner-linn.com
Correspondent Name: GARDNER, LINN, BURKHART & ONDERSMA LLP
Address Line 1: 2900 CHARLEVOIX DRIVE SE
Address Line 2: SUITE 300
Address Line 4: GRAND RAPIDS, MICHIGAN 49546

ATTORNEY DOCKET NUMBER:	RYZ01 A-122
NAME OF SUBMITTER:	KARL T. ONDERSMA
SIGNATURE:	/Karl T. Ondersma/

DATE SIGNED:	04/11/2022
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 4
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CSCL/CD-754 (Rev. 07/19)

MICHIGAN DEPARTMENT OF LICENSING AND REGULATORY AFFAIRS
CORPORATIONS, SECURITIES & COMMERCIAL LICENSING BUREAU

Date Received
JUN 30 2021

(FOR BUREAU USE ONLY)

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This document is effective on the date filed, unless a subsequent effective date within 90 days after received date is stated in the document.

FILED

JUN 30 2021

ADMINISTRATOR
CORPORATIONS DIVISION

Name
Darren Bartlette

Address
Dentons US LLP 22 Little W 12th Street

City | State | ZIP Code
New York, NY 10014

Document will be returned to the name and address you enter above. If left blank, document will be returned to the registered office.

EFFECTIVE DATE:

Expiration date for new assumed names: December 31,

Expiration date for transferred assumed names appear on page 2.

CERTIFICATE OF CONVERSION
For use by a Limited Liability Company Converting into a Business Organization

Pursuant to the provisions of Act 284, Public Acts of 1972 (profit corporations), Act 162, Public Acts of 1982 (nonprofit corporation) and Act 23, Public Acts of 1993 (limited liability companies), the undersigned limited liability company executes the following Certificate of Conversion.

1. Before Conversion

Entity Name:	Entity ID
OPS Solutions LLC	801342542

Indicate (X) Entity Type	☒	Domestic Limited Liability Company
		Street Address, if different than the one provided in Item 3: 48443 Alpha Drive, Suite 175 Wixom, MI USA 48393
	☐	Foreign Limited Liability Company

2. After Conversion

Entity Name:
LightGuide, Inc.

Indicate (X) Entity Type	☐	Domestic Profit Corporation
	☐	Domestic Nonprofit Corporation
	☒	Foreign Profit Corporation
	☐	Foreign Nonprofit Corporation
	☐	Domestic Limited Liability Company
	☐	Foreign Limited Liability Company

If the converting limited liability company is a domestic limited liability company that has not commenced business, has not issued any membership interests; has no debts or other liabilities, and has not received or returned any payments for its membership interests, proceed to Item 4.

If the converting limited liability company is a domestic limited liablity company that has commenced business or a foreign limited liability company, proceed to Item 3.

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3. Surviving Business Organization (After Conversion Entity)

Governing Statute: Delaware Corporation Act
Street Address: 48443 Alpha Drive, Suite 175 Wixom, MI USA 48393
Principal Place of Business: 48443 Alpha Drive, Suite 175 Wixom, MI USA 48393

4. (Complete only if a later effective date is desired other than the date of filing. The date must be no more than 90 days after the receipt of this document by the administrator.)

The conversion is effective on the _____ day of _____ , _____ .

The plan of conversion will be furnished by the surviving business organization, on request and without cost, to any member of the converting limited liability company.

The conversion is permitted by the law that will govern the internal affairs of the business organization after conversion and the surviving business organization complies with that law in converting.

5. The assumed names being transferred to continue for the remaining effective period of the Certificate of Assumed Name on file prior to the conversion are:

Assumed Name	Expiration Date

6. The converting limited liability company's name and/or assumed name(s) to be used as new assumed name(s) of the surviving business organization:

Assumed Name

7. **Signatures**: Complete only Section (a) or (b) if the converting entity is a domestic limited liability company. Proceed to Item 8 if the before conversion entity is a foreign limited liability company.

Complete if the domestic limited liability company has not commenced business:

a) The domestic limited liability company has not yet commenced business, has not issued any membership interests; has no debts or other liabilities, and has not received or returned any payments for its membership interests and the plan of conversion was adopted and approved by unanimous consent of the organizers, in accordance with Section 708(1)(d) of the Act.

Signed this_____ day of _____, _____.

(Signature of Organizer)	(Signature of Organizer)
(Type or Print Name)	(Type or Print Name)
(Signature of Organizer)	(Signature of Organizer)
(Type or Print Name)	(Type or Print Name)

Complete if the domestic limited liability company has commenced business:

b) The plan of conversion was adopted and approved by the unanimous vote of the members, entitled to vote, unless the articles of organization or operating agreement provide otherwise, in accordance with Section 708(1)(c) of the Act.

Signed this 29th day of June, 2021.

By DocuSigned by: Paul Ryznar 64C4C22B53B2D4D8...
(Signature of Member, Manager or Authorized Agent)

Paul Ryznar
(Type or Print Name)

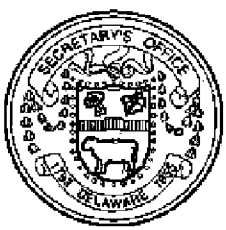
Delaware

The First State

I, JEFFREY W. BULLOCK, SECRETARY OF STATE OF THE STATE OF DELAWARE, DO HEREBY CERTIFY "LIGHTGUIDE, INC." IS DULY INCORPORATED UNDER THE LAWS OF THE STATE OF DELAWARE AND IS IN GOOD STANDING AND HAS A LEGAL CORPORATE EXISTENCE SO FAR AS THE RECORDS OF THIS OFFICE SHOW, AS OF THE THIRTIETH DAY OF JUNE, A.D. 2021.

AND I DO HEREBY FURTHER CERTIFY THAT THE SAID "LIGHTGUIDE, INC." WAS INCORPORATED ON THE TWENTY-NINTH DAY OF JUNE, A.D. 2021.

AND I DO HEREBY FURTHER CERTIFY THAT THE ANNUAL FRANCHISE TAXES HAVE BEEN ASSESSED TO DATE.





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SR# 20212589666

Authentication: 203569796

Date: 06-30-21

You may verify this certificate online at corp.delaware.gov/authver.shtml