This file wrapper was thoroughly reviewed by our technical staff. The file history jacket cover and table of contents are missing from the original USPTO file history.

This has been brought to your attention so that you will know it has not been overlooked.

Bibliographic Data

Application No: 16/953,771

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /BRYAN EARLES/ Examiner's Signature | Initials

Title: ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/20/2020	345	2625	250303-1022
RULE			

APPLICANTS

CM HK LIMITED, Fortress Hill, HONG KONG

INVENTORS

Shun-Nan LIOU, Taipei, TAIWAN

Zhou YE, Taipei, TAIWAN

Chin-Lung LI, Taipei, TAIWAN

CONTINUING DATA

This application is a CON of 15611970 06/02/2017 PAT 10852846

15611970 is a CON of 13072794 03/28/2011 PAT 9760186

13072794 is a CIP of 12943934 11/11/2010 PAT 8441438

12943934 has PRO of 61292558 01/06/2010

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

12/15/2020

**** SMALL ENTITY ****

STATE OR COUNTRY

TAIWAN

ADDRESS

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 550
Atlanta, GA 30339
UNITED STATES

FILING FEE RECEIVED

$1,230

Electronic Patent Application Fee Transmittal	
Application Number:	
Filing Date:	
Title of Invention:	Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof
First Named Inventor/Applicant Name:	Shun-Nan LIOU
Filer:	Michael P. Qualey/Brooke French
Attorney Docket Number:	250303-1022
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	80	80
UTILITY SEARCH FEE	2111	1	350	350
UTILITY EXAMINATION FEE	2311	1	400	400
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	2202	8	50	400
Miscellaneous-Filing:				
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1230**

Electronic Acknowledgement Receipt	
EFS ID:	41183167
Application Number:	16953771
International Application Number:	
Confirmation Number:	1038
Title of Invention:	Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof
First Named Inventor/Applicant Name:	Shun-Nan LIOU
Customer Number:	109673
Filer:	Michael P. Qualey/Brooke French
Filer Authorized By:	Michael P. Qualey
Attorney Docket Number:	250303-1022
Receipt Date:	20-NOV-2020
Filing Date:	
Time Stamp:	13:35:14
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1230
RAM confirmation Number	E2020AJD36054141
Deposit Account	505954
Authorized User	Brooke French
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 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	Application Data Sheet	00843561.PDF	1823618 f27cd2be99303b0f6c03648b12b5035a086066b0	no	9
Warnings:					
Information:					
2		00843575.PDF	272748 24d3a10edb5b7e7a66b65052c03caa0a8f4de6d7	yes	67

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Abstract	67	67
	Claims	59	66
	Specification	1	58

Warnings:					
Information:					
3	Drawings-only black and white line drawings	00843555.PDF	327358 d68a37c947e36fbd32745b3019fb4e4a1fcb61c7	no	10
Warnings:					
Information:					
4	Oath or Declaration filed	00843552.PDF	2468205 faf52411b9e43a702792ffe9f97317f46b198f14	no	8
Warnings:					
Information:					
5	Transmittal Letter	00843582.PDF	84528 7ac9c53519eba7c999cf9c177790a3663a2da96b	no	3

Warnings:					
Information:					
6	Information Disclosure Statement (IDS) Form (SB08)	00843564.PDF	1036707 79c007ce964e6a23359e58ce5da52a5234a81499	no	10
Warnings:					
Information:					
7	Power of Attorney	00843580.PDF	1086540 a81dafe35381c89baa75ab8a4f05a5c6f27b7434	no	2
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
8	Fee Worksheet (SB06)	fee-info.pdf	37001 96e2e40108b812e22641a8e931efe19328fdd131	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	7136705		

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.

<u>New Applications Under 35 U.S.C. 111</u>
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.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
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.
<u>New International Application Filed with the USPTO as a Receiving Office</u>
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.

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	250303-1022
	Application Number	
Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	

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
	Shun-Nan		LIOU	

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

City	Country of Residence [i]
Taipei	TW

Mailing Address of Inventor:

Address 1	5F-2, No.12, Wenhu St., Neihu Dist.
Address 2	
City	Taipei
State/Province	
Postal Code	11445
Country [i]	TW

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Zhou		YE	

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

City	Country of Residence [i]
Taipei	TW

Mailing Address of Inventor:

Address 1	5F-2, No.12, Wenhu St., Neihu Dist.
Address 2	
City	Taipei
State/Province	
Postal Code	11445
Country [i]	TW

Inventor 3 Remove

Legal Name

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	250303-1022
	Application Number	
Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Chin-Lung		LI	

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

City	Taipei	Country of Residence i	TW

Mailing Address of Inventor:

Address 1	5F-2, No.12, Wenhu St., Neihu Dist.		
Address 2			
City	Taipei	**State/Province**	
Postal Code	11445	**Country** i	TW

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).

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

Customer Number	109673		
Email Address	paul.qualey@mqrlaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF		
Attorney Docket Number	250303-1022	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	10	**Suggested Figure for Publication (if any)**	

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 i

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	250303-1022
	Application Number	
Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	

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	109673		

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	15611970	2017-06-02

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
15611970	Continuation of	13072794	2011-03-28	9760186	2017-09-12

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13072794	Continuation in part of	12943934	2010-11-11	8441438	2013-05-14

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12943934	Claims benefit of provisional	61292558	2010-01-06

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	250303-1022
	Application Number	
Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	

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

☐ 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.

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	250303-1022
	Application Number	
Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	

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.

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	250303-1022
	Application Number	
Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	

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	CM HK LIMITED		
Mailing Address Information For Applicant:			
Address 1	RM 2401 24/F 101 KING'S RD		
Address 2			
City	FORTRESS HILL	**State/Province**	
Country	HK	Postal Code	
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)
Approved for use through 04/30/2017. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	250303-1022
	Application Number	
Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	

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	/M.PaulQualey,Jr./			Date (YYYY-MM-DD)	2020-11-20
First Name	M. Paul	Last Name	Qualey, Jr.	Registration Number	43,024

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

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	250303-1022
	Application Number	
Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	

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.**

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 the Freedom of Information Act requires disclosure of these records.

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 CooperationTreaty.

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 inspections 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 DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation application, which claims the benefit of and priority to U.S. application Ser. No. 15/611,970, filed on June 2, 2017, which claims the benefit of and priority to U.S. application Ser. No. 13/072,794, filed on March 28, 2011 (now U.S. Patent No. 9,760,186, issued on September 12, 2017), which is a continuation in part of and claims the priority benefit of U.S. application serial no. 12/943,934, filed on November 11, 2010, now patented as U.S. Patent No. 8,441,438, issued on May 14, 2013, which claims the priority benefit of U.S. application serial no. 61/292,558, filed on January 06, 2010. The entirety of each of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of this specification.

[0002]

BACKGROUND OF THE INVENTION

Field of the Invention

[0003] The present invention generally relates to an electronic device, more particularly to an electronic device for use in computers, motion detection or navigation utilizing a motion sensor module and method of compensating signals of the motion sensor module subject to movements and rotations of said electronic device. The present invention utilizes a nine-axis motion sensor module with an enhanced comparison model to calculate and compensate accumulated errors associated with the motion sensor module and to obtain actual resulting deviation angles in spatial

reference frame and under dynamic environments.

Description of the Related Art

[0004] Fig. 1 is a schematic diagram showing a user using a portable electronic device 110, such as a 3D pointing device or computer mouse, for detecting motions of the device and translating the detected motions to a cursor display such as a cursor pointing on the screen 122 of a 2D display device 120. If the pointing device 110 emits a light beam, the corresponding point would be the location where the light beam hits the screen 122. For example, the pointing device 110 may be a mouse of a computer or a pad of a video game console. The display device 120 may be a part of the computer or the video game console. There are two reference frames, such as the spatial pointer reference frame and the display frame, associated with the pointing device 110 and the display device 120, respectively. The first reference frame or spatial pointer reference frame associated with the pointing device 110 is defined by the coordinate axes X_P, Y_P and Z_P as shown in Fig. 1. The second reference frame or display frame associated with the display device 120 is defined by the coordinate axes X_D, Y_D and Z_D as shown in Fig. 1. The screen 122 of the display device 120 is a subset of the X_DY_D plane of the reference frame $X_DY_DZ_D$ associated with the display device 120. Therefore, the X_DY_D plane is also known as the display plane associated with the display device 120.

[0005] A user may perform control actions and movements utilizing the pointing device for certain purposes including entertainment such as playing a video game, on the display device 120 through the aforementioned pointer on the screen 122. For proper interaction with the use of the pointing device, when the user moves the pointing device 110, the pointer on the screen 122 is

expected to move along with the orientation, direction and distance travelled by the pointing device 110 and the display 120 shall display such movement of the pointer to a new location on the screen 122 of the display 120. The orientation of the pointing device 110 may be represented by three deviation angles of the 3D pointing device 110 with respect to the reference frame $X_PY_PZ_P$, namely, the yaw angle 111, the pitch angle 112 and the roll angle 113. The yaw, pitch and roll angles 111, 112, 113 may be best understood in relation to the universal standard definition of spatial angles related to commercial vehicles or transportation such as ships and airplanes. Conventionally, the yaw angle 111 may represent the rotation of the pointing device 110 about the Z_P axis; the pitch angle 112 may represent the rotation of the pointing device 110 about the Y_P axis; the roll angle 113 may represent the rotation of the pointing device 110 about the X_P axis.

[0006] In a known related art as shown in Fig. 1, when the yaw angle 111 of the pointing device 110 changes, the aforementioned pointer on the screen 122 must move horizontally or in a horizontal direction with reference to the ground in response to the change of the yaw angle 111. Fig. 2 shows what happens when the user rotates the pointing device 110 counterclockwise by a degree such as a 90-degree about the X_P axis. In another known related art as shown in Fig. 2, when the yaw angle 111 changes, the aforementioned pointer on the screen 122 is expected to move vertically in response. The change of the yaw angle 111 can be detected by a gyro-sensor which detects the angular velocity ω_x of the pointing device 110 about the X_P axis. Fig. 1 and Fig. 2 show that the same change of the yaw angle 111 may be mapped to different movements of the point on the screen 122. Therefore, a proper compensation mechanism for the orientation of the pointing device 110 is required such that corresponding mapping of the pointer on the screen 122 of the display 120 may be obtained correctly and desirably. The term compensation of the prior

arts by Liberty (US Patent No. 7,158,118, US Patent No. 7,262,760 and US Patent No. 7,414,611) refers to the correction and compensation of signals subject to gravity effects or extra rotations about the axis related to "roll". The term of "comparison" of the present invention may generally refer to the calculating and obtaining of the actual deviation angles of the 3D pointing device 110 with respect to the first reference frame or spatial pointing frame $X_PY_PZ_P$ utilizing signals generated by motion sensors while reducing or eliminating noises associated with said motion sensors; whereas the term mapping may refer to the calculating and translating of said deviation angles in the spatial pointing frame $X_PY_PZ_P$ onto the aforementioned pointer on the display plane associated with the 2D display device 120 of a second reference frame or display frame $X_DY_DZ_D$.

[0007] It is known that a pointing device utilizing 5-axis motion sensors, namely, Ax, Ay, Az, ω_Y and ω_Z may be compensated. For example, US Patent No. 7,158,118 by Liberty, US Patent 7,262,760 by Liberty and US 7,414,611 by Liberty provide such pointing device having a 5-axis motion sensor and discloses a compensation using two gyro-sensors ω_Y and ω_Z to detect rotation about the Yp and Zp axes, and accelerometers Ax, Ay and Az to detect the acceleration of the pointing device along the three axes of the reference frame $X_PY_PZ_P$. The pointing device by Liberty utilizing a 5-axis motion sensor may not output deviation angles of the pointing device in, for example, a 3D reference frame; in other words, due to due to the limitation of the 5-axis motion sensor of accelerometers and gyro-sensors utilized therein, the pointing device by Liberty cannot output deviation angles readily in 3D reference frame but rather a 2D reference frame only and the output of such device having 5-axis motion sensors is a planar pattern in 2D reference frame only. In addition, it has been found that the pointing device and compensation disclosed therein cannot accurately or properly calculate or obtain movements, angles and directions of the pointing device

while being subject to undesirable interferences, external or internal, in the dynamic environment during the obtaining of the signals generated by the motion sensors, in particular, during unexpected drifting movements and/or accelerations along with the direction of gravity. In other words, it has been found that dynamic actions or extra accelerations including additional accelerations, in particular the one acted upon the direction substantially parallel to or along with the gravity imposed on the pointing device with the compensation methods provided by Liberty, said pointing device by Liberty cannot properly or accurately output the actual yaw, pitch and roll angles in the spatial reference frame $X_PY_PZ_P$ and following which, consequently, the mapping of the spatial angles onto any 2D display reference frame such as $X_DY_DZ_D$ may be greatly affected and erred. To be more specific, as the 5-axis compensation by Liberty cannot detect or compensate rotation about the X_P axis directly or accurately, the rotation about the X_P axis has to be derived from the gravitational acceleration detected by the accelerometer. Furthermore, the reading of the accelerometer may be accurate only when the pointing device is static since due to the limitation on known accelerometers that these sensors may not distinguish the gravitational acceleration from the acceleration of the forces including centrifugal forces or other types of additional accelerations imposed or exerted by the user.

[0008] Furthermore, it has been found that known prior arts may only be able to output a "relative" movement pattern in a 2D reference frame based on the result calculated from the signals of motion sensors. For example, the abovementioned prior arts by Liberty may only output a 2D movement pattern in a relative manner and a pointer on a display screen to show such corresponding 2D relative movement pattern. To be more specific, the pointer moves from a first location to a second new location relative to said first location only. Such relative movement from

the previous location to the next location with respect to time cannot accurately determine and/or output the next location, particularly in situations where the previous location may have been an erred location or have been faultily determined as an incorrect reference point for the next location that is to be calculated therefrom and obtained based on their relative relationship adapted. One illustration of such defect of known prior arts adapting a relative relationship in obtaining a movement pattern may be clearly illustrated by an example showing the faultily outputted movements of a pointer intended to move out of a boundary or an edge of display screen. It has been found that as the pointer of known prior arts reaches the edge of a display and continues to move out of the boundary or edge at a certain extra extent beyond said boundary, the pointer fails to demonstrate a correct or "absolute" pattern as it moves to a new location either within the display or remaining outside of the boundary; in other words, instead of returning to a new location by taking into account said certain extra extend beyond the boundary made earlier in an "absolute" manner, the pointer of known arts discards such virtual distance of the extra extend beyond the boundary already made and an erred next position is faultily outputted due to the relative relationship adapted and utilized by the pointer. may be never calculated or processed due to the faultily obtained location at the edge or boundary of the display as well as the relative relationship adapted to obtain its next location therefrom.

[0009] Therefore, it is clear that an improved device for use in for example motion detection, computers or navigation with enhanced calculating or comparison method capable of accurately obtaining and calculating actual deviation angles in the spatial pointer frame is needed. For applications of navigations or computers including portable communication devices integrated with displays therein, the electronic device may too include the mapping of such actual angles onto

a cursor, pointer or position information on the display frame in dynamic environments and conditions including undesirable external interferences. In addition, as the trend of 3D technology advances and is applicable to various fields including displays, interactive systems and navigation, there is a significant need for an electronic device, including for example a motion detector, a 3D pointing device, a navigation equipment, or a communication device integrated with motion sensors therein, capable of accurately outputting a deviation of such device readily useful in a 3D or spatial reference frame. Furthermore, there is a need to provide an enhanced comparison method and/or model applicable to the processing of signals of motion sensors such that errors and/or noises associated with such signals or fusion of signals from the motions sensors may be corrected or eliminated. In addition, according to the field of application, such output of deviation in 3D reference frame may too be further mapped or translated to a pattern useful in a 2D reference frame.

SUMMARY OF THE INVENTION

[0010] According to one aspect of an exemplary embodiment of the present invention, an electronic device utilizing a nine-axis motion sensor module for use in for example computers, motion detection or navigation is provided. The electronic device comprises an accelerometer to measure or detect axial accelerations Ax, Ay, Az, a magnetometer to measure or detect magnetism Mx, My, Mz and a rotation sensor to measure or detect angular velocities ω_x, ω_y, ω_z such that resulting deviation including resultant angles comprising yaw, pitch and roll angles in a spatial pointer frame of the electronic device subject to movements and rotations in dynamic environments may be obtained and such that said resulting deviation including said resultant angles may be obtained and outputted in an absolute manner reflecting or associating with the actual movements and rotations of the electronic device of the present invention in said spatial pointer

reference frame and preferably excluding undesirable external interferences in the dynamic environments.

[0011] According to another aspect of the present invention, the present invention provides an enhanced comparison method and/or model to eliminate the accumulated errors as well as noises over time associated with signals generated by a combination of motion sensors, including the ones generated by accelerometers A_x, A_y, A_z, the ones generated by magnetometers M_x, M_y, M_z and the ones generated by gyroscopes ω_x, ω_y, ω_z in dynamic environments. In other words, accumulated errors associated with a fusion of signals from a motions sensor module comprising a plurality of motion sensors to detect movements on and rotations about different axes of a reference frame may be eliminated or corrected.

[0012] According to still another aspect of the present invention, the present invention provides an enhanced comparison method to correctly calculating and outputting a resulting deviation comprising a set of resultant angles including yaw, pitch and roll angles in a spatial pointer frame, preferably about each of three orthogonal coordinate axes of the spatial pointer reference frame, by comparing signals of rotation sensor related to angular velocities or rates with the ones of accelerometer related to axial accelerations and the ones of magnetometer related to magnetism such that these angles may be accurately outputted and obtained, which may too be further mapping to another reference frame different from said spatial pointer frame.

[0013] In the event of interferences including external interferences introduced by either the device user or the surrounding environment, such as external electromagnetic fields, according to

still another aspect of the present invention, the present invention provides a unique update program comprising a data association model to intelligently process signals received from a motion sensor module to output a resultant deviation preferably in 3D reference frame such that the adverse effects caused by the interferences may be advantageously reduced or compensated.

[0014] According to still another aspect of the present invention, the present invention further provides a mapping of the abovementioned resultant angles, preferably about each of three orthogonal coordinate axes of the spatial pointer reference frame, including yaw, pitch and roll angles in a spatial pointer reference frame onto a display frame either external to the device of the present invention or integrated therein such that a movement pattern in a display frame different from the spatial pointer reference frame may be obtained according to the mapping or translation of the resultant angles of the resultant deviation onto said movement pattern.

[0015] According to another example embodiment of the present invention, an electronic device capable of generating 3D deviation angles and for use in for example computers, motion detection or navigation is provided. The electronic device may utilize a nine-axis motion sensor module with an enhanced comparison method or model for eliminating accumulated errors of said nine-axis motion sensor module to obtain deviation angles corresponding to movements and rotations of said electronic device in a spatial pointer reference frame. The comparison method or model may be advantageously provided by comparing signals from the abovementioned nine-axis motion sensor module capable of detecting rotation rates or angular velocities of the electronic device about all of the X_P, Y_P and Z_P axes as well as axial accelerations and ambient magnetism including such as earth's magnetic field or that of other planets of the electronic device along all of the X_P,

Y_P and Z_P axes such that deviation angles of the resultant deviation of the electronic device of the present invention may be preferably obtained or outputted in an absolute manner. In other words, the present invention is capable of accurately outputting the abovementioned deviation angles including yaw, pitch and roll angles in a 3D spatial pointer reference frame of the 3D pointing device to eliminate or reduce accumulated errors and noises generated over time in a dynamic environment including conditions such as being subject to a combination of continuous movements, rotations, external gravity forces, magnetic field and additional extra accelerations in multiple directions or movement and rotations that are continuously nonlinear with respect to time; and furthermore, based on the deviation angles being compensated and accurately outputted in 3D spatial reference frame may be further mapped onto or translated into another reference frame such as the abovementioned display frame, for example a reference in two-dimension (2D).

[0016] According to another example embodiment of the present invention, a 3D pointing device utilizing a nine-axis motion sensor module is provided; wherein the nine-axis motion sensor module of the 3D pointing device comprises at least one gyroscope, at least one accelerometer and at least one magnetometer. In one preferred embodiment of the present invention, the nine-axis motion sensor module comprises a rotation sensor capable of detecting and generating angular velocities of ω_x, ω_y, ω_z, an accelerometer capable of detecting and generating axial accelerations of Ax, Ay, Az, and a magnetometer capable of detecting and generating magnetism of Mx, My, Mz. It can be understood that in another embodiment, the abovementioned rotation sensor may comprise three gyroscopes corresponding to each of the said angular velocities of ω_x, ω_y, ω_z in a 3D spatial reference frame of the 3D pointing device; whereas the abovementioned accelerometer may comprise three accelerometers corresponding to each of the said axial accelerations Ax, Ay,

Az in a 3D spatial reference frame of the 3D pointing device; and whereas the abovementioned magnetometer may comprise three magnetic sensors such as magneto-impedance (MI) sensors or magneto-resistive (MR) sensors corresponding to each of the said magnetism Mx, My, Mz in a 3D spatial reference frame of the electronic device. The rotation sensor detects the rotation of the 3D pointing device with respect to a reference frame associated with the 3D pointing device and provides a rotation rate or angular velocity output. The angular velocity output includes three components corresponding to the rotation rate or angular velocities ω_x, ω_y, ω_z of the 3D pointing device about the first axis, the second axis and the third axis of the reference frame, namely, Xp, Yp and Zp of the 3D spatial frame. The accelerometer detects the axial accelerations of the 3D pointing device with respect to the spatial reference frame such as a 3D-pointer reference frame and provides an acceleration output. The acceleration output includes three components corresponding to the accelerations, Ax, Az, Ay of the 3D pointing device along the first axis, the second axis and the third axis of the reference frame, namely, Xp, Yp and Zp of the 3D spatial reference frame. The magnetometer detects the magnetism of the electronic device with respect to the spatial reference frame such as a 3D reference frame and provides an magnetism output. The magnetism output includes three components corresponding to the magnetism, Mx, My, Mz of the 3D pointing device along the first axis, the second axis and the third axis of the reference frame, namely, Xp, Yp and Zp of the 3D spatial frame. It can, however, be understood that the axes of Xp, Yp and Zp of the 3D spatial reference frame may too be represented simply by the denotation of X, Y and Z.

[0017] According to another example embodiment of the present invention, a method for compensating accumulated errors of signals of the abovementioned nine-axis motion sensor

module in dynamic environments associated in a spatial reference frame is provided. In one embodiment, the method may be performed or handled by a hardware processor. The processor is capable of compensating the accumulated errors associated with the resultant deviation in relation to the signals of the abovementioned nine-axis motion sensor module of the 3D pointing device subject to movements and rotations in a spatial reference frame and in a dynamic environment by performing a data comparison to compare signals of rotation sensor related to angular velocities with the ones of accelerometer related to axial accelerations and the ones of magnetometer related to magnetism such that the resultant deviation corresponding to the movements and rotations of the 3D pointing device in the 3D spatial reference frame may be obtained accurately over time in the dynamic environments.

[0018] According to another embodiment of the present invention, a method for obtaining a resulting deviation including resultant angles in a spatial reference frame of a three-dimensional (3D) pointing device utilizing a nine-axis motion sensor module therein and subject to movements and rotations in dynamic environments in said spatial reference frame is provided. Said method comprises the steps of: obtaining a previous state associated with previous angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the nine-axis motion sensor module at a previous time T-1; obtaining a current state of the nine-axis motion sensor module by obtaining measured angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals at a current time T; obtaining a measured state of the nine-axis motion sensor module by obtaining measured axial accelerations Ax, Ay, Az and measured magnetism M_x, M_y, M_z gained from the motion sensor signals at the current time T and calculating predicted axial accelerations Ax', Ay', Az' and predicted magnetism M_x', M_y', M_z' based on the measured angular velocities ω_x, ω_y, ω_z of the current state;

obtaining an updated state of the nine-axis motion sensor module by comparing the current state with the measured state of the nine-axis motion sensor module; and calculating and converting the updated state of the nine-axis motion sensor module to said resulting deviation comprising said resultant angles in said spatial reference frame of the 3D pointing device.

[0019] According to another aspect of the present invention, a method for mapping deviation angles associated with movements and rotations of a 3D pointing device in a spatial reference frame onto a display frame of a display having a predetermined screen size is provided. In one embodiment, the method for mapping or translating deviation angles including yaw, pitch and roll angles in a spatial reference frame to an pointing object, such as a pointer, having movements in a display frame, preferably a 2D reference frame, comprises the steps of obtaining boundary information of the display frame by calculating a predefined sensitivity associated with the display frame and performing angle and distance translation in the display frame based on said deviation angles and boundary information.

[0020] According to another embodiment of the present invention, a method for obtaining a resulting deviation including resultant angles in a spatial reference frame of a three-dimensional pointing device utilizing a nine-axis motion sensor module therein and subject to movements and rotations in dynamic environments in said spatial reference frame is provided. Said method comprises the steps of: obtaining a previous state of the nine-axis motion sensor module; wherein the previous state includes an initial-value set associated with at least previous angular velocities gained from the motion sensor signals of the nine-axis motion sensor module at a previous time T-1; obtaining a current state of the nine-axis motion sensor module by obtaining measured angular

velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the nine-axis motion sensor module at a current time T; obtaining a measured state of the nine-axis motion sensor module by obtaining measured axial accelerations Ax, Ay, Az gained from the motion sensor signals of the nine-axis motion sensor module at the current time T and calculating predicted axial accelerations Ax', Ay', Az' based on the measured angular velocities ωx, ωy, ωz of the current state of the nine-axis motion sensor module; obtaining a first updated state of the nine-axis motion sensor module by comparing the current state with the measured state of the nine-axis motion sensor module; obtaining the measured state of the nine-axis motion sensor module by obtaining and calculating a measured yaw angle gained from the motion sensor signals of the nine-axis motion sensor module at the current time T and calculating a predicted yaw angle based on the first updated state of the nine-axis motion sensor module; obtaining a second updated state of the nine-axis motion sensor module by comparing the current state with the measured state of the nine-axis motion sensor module; and calculating and converting the second updated state of the nine-axis motion sensor module to said resulting deviation comprising said resultant angles in said spatial reference frame of the electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated herein for illustrative purposes only. The drawings illustrate embodiments of the invention and, together with the description, serve to only illustrate the principles of the invention.

[0022] FIG. 1 shows a known related art having a 5-axis motion sensor in 2D reference frame.

[0023] FIG. 2 shows the known related art having a 5-axis motion sensor as shown in FIG.1 being rotated or rolled about Xp axis and is subject to further dynamic interactions or environment.

[0024] FIG. 3 is an exploded diagram showing an electronic device of the present invention, such as a pointing device, utilizing a nine-axis motion sensor module according to one embodiment of the present invention.

[0025] FIG. 4 is a schematic block diagram illustrating hardware components of an electronic device according to one embodiment of the present invention.

[0026] FIG. 5 is a schematic diagram showing another embodiment of an electronic device of the present invention, such as a pointing device, utilizing a nine-axis motion sensor module as well as an external processor.

[0027] FIG. 6 is an exploded diagram showing still another embodiment of an electronic device of the present invention, such as a smartphone or navigation equipment, utilizing a nine-axis motion sensor module according to anther embodiment of the present invention.

[0028] FIG. 7 is a flow chart illustrating a method for obtaining a resultant deviation of an electronic device of the present invention subject to movements and rotations in a spatial reference frame.

[0029] FIG. 8 shows another exemplary flow chart illustrating a method for obtaining resultant deviation including mapping of said deviation to a display of an electronic device according to another embodiment of the present invention.

[0030] FIG. 9 is a schematic diagram showing the mapping of the resultant angles of the resultant deviation according to an embodiment of the present invention.

[0031] FIG. 10 is an exemplary flow chart illustrating another embodiment of a method for obtaining a resultant deviation of an electronic device of the present invention.

[0032] FIG. 11 shows an exemplary flow chart illustrating another embodiment of a method for obtaining a resultant deviation including mapping of such deviation to a display of an electronic device of the present invention.

[0033] FIG. 12 shows an exemplary flow chart illustrating a method for obtaining resultant deviation of an electronic device according to still another embodiment of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0034] Detailed descriptions of preferred embodiments of the present invention recited herein are provided for illustrative purposes only; examples of which are too illustrated in the accompanying drawings. In addition, similar reference numbers in the drawings and the description may too refer to similar parts or components.

[0035] FIG. 3 is an exploded diagram showing an electronic device 300 according to one embodiment of the present invention, such as a pointing device. The electronic device 300 is subject to movements and rotations in dynamic environments in a spatial reference frame such as a 3D reference frame. The spatial reference frame is analogous to the reference frame $X_P Y_P Z_P$ also shown in Fig. 1 and Fig. 2. The movements and rotations of the electronic device 300, such as a pointing device, in the aforementioned dynamic environments in the spatial reference frame may be continuously nonlinear with respect to time. The term of "dynamic" recited herein may refer to moving or subject to motions in general.

[0036] The electronic device 300 includes a top cover 310, a printed circuit board (PCB) 340, a rotation sensor 342, an accelerometer 344, a magnetometer 345, a data transmitting unit 346, a computing processor 348, a bottom cover 320, and a battery pack 322. The top cover 310 may include a few control buttons 312 for a user to issue predefined commands for remote control. In one embodiment, the housing 330 may comprise the top cover 310 and the bottom cover 320. The housing 330 may move and rotate in the spatial reference frame according to user manipulation or any external forces in any direction and/or under the abovementioned dynamic environments. As shown in the FIG.3, in one embodiment, the rotation sensor 342, the accelerometer 344, the magnetometer 345, the data transmitting unit 346, and the computing processor 348 may be all attached to the PCB 340. The PCB 340 is enclosed by the housing 330. The PCB 340 includes at least one substrate having a longitudinal side configured to be substantially parallel to the longitudinal surface of the housing 330. An additional battery pack 322 provides electrical power for the electronic device 300.

[0037] Furthermore, in one embodiment, the abovementioned dynamic environments, in which the electronic device 300 of the present invention may be present or subject to, may include undesirable external interferences to the electronic device 300 of the present invention. In one example, the undesirable external interferences may refer to or include undesirable axial accelerations caused by undesirable external forces other than a force of gravity. In another example, the undesirable external interferences may also refer to or include undesirable magnetism caused by undesirable electromagnetic fields.

[0038] FIG. 4 is a schematic block diagram illustrating hardware components of the electronic device 300. The electronic device 300 includes a nine-axis motion sensor module 302 and a processing and transmitting module 304. The nine-axis motion sensor module 302 includes the rotation sensor 342, the accelerometer 344 and the magnetometer 345. The processing and transmitting module 304 includes the data transmitting unit 346 and the computing processor 348.

[0039] The term "nine-axis" recited herein may refer to and generally include the three angular velocities ω_x, ω_y, ω_z, the three axial accelerations Ax, Ay, Az, and the three magnetism Mx, My, Mz. The rotation sensor 342 of the nine-motion sensor module 302 detects and generates the first signal set including angular velocities ω_x, ω_y, ω_z associated with the movements and rotations of the electronic device 300 about each of three orthogonal coordinate axes $X_PY_PZ_P$ of the spatial reference frame. The angular velocities ω_x, ω_y and ω_z are corresponding to the coordinate axes X_P, Y_P and Z_P respectively. The accelerometer 344 detects and generates the second signal set including axial accelerations Ax, Ay, Az associated with the movements and rotations of the electronic device 300 along each of the three orthogonal coordinate axes $X_PY_PZ_P$ of the spatial

reference frame. The axial accelerations Ax, Ay and Az are corresponding to the coordinate axes X_P, Y_P and Z_P respectively. The magnetometer 345 of the nine-motion sensor module 302 detects and generates the third signal set including magnetism Mx, My, Mz associated with the movements and rotations of the electronic device 300 along each of the three orthogonal coordinate axes $X_PY_PZ_P$ of the spatial reference frame. The magnetism Mx, My and Mz represent the strength and/or direction of ambient magnetic field (such as the magnetic field of the Earth) of the electronic device 300. The magnetism Mx, My and Mz are corresponding to the coordinate axes X_P, Y_P and Z_P respectively. It too can be understood that the abovementioned nine axes of $X_pY_pZ_p$ may not need to be orthogonal in a specific orientation and they may be rotated in different orientations; the present invention discloses such coordinate system for illustrative purposes only and any coordinates in different orientation and/or denotations may too be possible.

[0040] Furthermore, in one embodiment of the present invention, the motion sensor module or nine-axis motion sensor module 302 of the electronic device 300 may refer to a Micro-Electro-Mechanical-System (MEMS) type of sensor. In an explanatory example, the abovementioned rotation sensor 342 of the nine-axis motion sensor module 302 may further comprise at least one resonating mass such that a movement of said at least one resonating mass along an axis of said spatial reference frame may be detected and measured by said rotation sensor using the Coriolis acceleration effect to generate said first signal set comprising angular velocities ωx, ωy, ωz in said spatial reference frame. It can be understood that for a three-axis rotation sensor of a MEMS type sensor, there may be positioned three resonating masses along each of X, Y and Z axes of the spatial reference frame to generate and obtain movements or displacements of the three resonating masses thereof. It can too be understood that the nine-axis motion sensor 302 of the present

invention may also include a three-axis accelerometer, a three-axis rotation sensor and a three-axis magnetometer in a MEMS structure.

[0041] The data transmitting unit 346 is electrically connected to the nine-axis motion sensor module 302 for transmitting the first, second and third signal sets. The data transmitting unit 346 transmits the first, second and third signal sets of the nine-axis motion sensor module 302 to the computing processor 348 preferably via electronic connections configured on the PCB 340. The computing processor 348 receives and calculates the first, second and third signal sets from the data transmitting unit 346. The computing processor 348 further communicates with the nine-axis motion sensor module 302 to calculate the resulting deviation of the electronic device 300 including three resultant angles preferably about each of the three axes of the spatial reference frame. The resultant angles include the yaw angle 111, the pitch angle 112 and the roll angle 113 as shown in Fig. 1 and Fig. 2. In order to calculate the resulting deviation, the computing processor 348 may utilize a comparison or algorithm to eliminate accumulated errors of the first, second and/or third signal sets of the nine-axis motion sensor module 302, whereby the resultant angles in the spatial reference frame, preferably about each of three orthogonal coordinate axes of the spatial reference frame, of the resulting deviation of the nine-axis motion sensor module 302 of the electronic device 300 is obtained under the aforementioned dynamic environments excluding the abovementioned undesirable external interferences and such that it is preferably obtained and outputted in an absolute manner reflecting or associating with the actual movements and rotations of the electronic device 300, including such as a pointing device, of the present invention in said spatial reference frame. In addition, said comparison utilized by the computing processor 348 may further comprise an update program to obtain an updated state of the nine-axis motion sensor

module based on a previous state associated with a first signal set in relation to the angular velocities ω_x, ω_y, ω_z and a measured state associated with both said second and third signal sets in relation to the axial accelerations Ax, Ay, Az as well as magnetism Mx, My, Mz. The abovementioned measured state may include a measurement of said second signal set or measured Ax, Ay, Az and a predicted measurement of Ax', Ay' and Az' obtained based on or calculated from a current state of the motion sensor module 302. In addition, the abovementioned measured state may too include a measurement of said third signal set or measured Mx, My, Mz and a predicted measurement of Mx', My' and Mz' obtained based on or calculated from the current state of the motion sensor module 302. Details of different "states" of the nine-axis motion sensor module 302 of the electronic device 300 of the present invention are provided in the later content.

[0042] In one embodiment, the computing processor 348 of the processing and transmitting module 304 may further include a mapping program for translating the resultant angles of the resulting deviation in the spatial reference frame to a movement pattern in a display reference frame different from the spatial reference frame. The display reference frame is analogous to the reference frame $X_DY_DZ_D$ in Fig. 1 and Fig. 2. The movement pattern may be displayed on a screen of a 2D display device similar to the display device 120 in Fig. 1 and Fig. 2. The mapping program translates the resultant angles, preferably about each of the three orthogonal coordinate axes of the spatial reference frame to the movement pattern according to a sensitivity input correlated to the display reference frame.

[0043] FIG. 5 is a schematic diagram showing an electronic device 500 utilizing a nine-axis motion sensor module according to anther embodiment of the present invention in a 3D spatial

reference frame. As shown in FIG. 5, the electronic device 500 may comprise two parts 560 and 570 in data communication with each other. In one embodiment, the first part 560 includes a top cover (not shown), a PCB 540, a nine-axis motion sensor module 502 comprising a rotation sensor 542, an accelerometer 544 and a magnetometer 545, a data transmitting unit 546, a bottom cover 520, and a battery pack 522. The data transmitting unit 546 transmits the first signal set (ω_x, ω_y, ω_z) generated by the rotation sensor 542 of the nine-motion sensor module 502 and the second signal set (Ax, Ay, Az) generated by the accelerometer 544 as well as the third signal set (Mx, My, Mz) generated by the magnetometer 545 of the nine-motion sensor module 502 to the data receiving unit 552 of the second part 570 via wireless communication or connection including wireless local area network (WLAN) based on IEEE 802.11 standards or Bluetooth™. It can be understood that in another embodiment, wired communication or connection via a physical cable or electrical wires connecting the first part 560 and the second part 570 may too be possible. In one embodiment of the present invention, the motion sensor module or nine-axis motion sensor module 502 of the electronic device 500 may refer to a MEMS type of sensor. In an explanatory example, the abovementioned rotation sensor 542 of the nine-axis motion sensor module 502 may further comprise at least one resonating mass such that a movement of said at least one resonating mass along an axis of said spatial reference frame may be detected and measured by said rotation sensor using the Coriolis acceleration effect to generate said first signal set comprising angular velocities ωx, ωy, ωz in said spatial reference frame. It can be understood that for a three-axis rotation sensor of a MEMS type sensor, there may be positioned three resonating masses along each of X, Y and Z axes of the spatial reference frame to generate and obtain movements or displacements of the three resonating masses thereof. It can too be understood that the nine-axis motion sensor 502 of the present invention may also include a three-axis accelerometer, a three-

axis rotation sensor and a three-axis magnetometer in a MEMS structure.

[0044] In one embodiment, the second part 570 may be an external processing device to be adapted to another electronic computing apparatus or system such as a standalone personal computer or server 580; for instance, the second part 570 may be coupled or adapted to an laptop computer via a standard interface, such as the universal serial bus (USB) interface depicted as shown in Fig. 5. The first part 560 and the second part 570 communicate via the data transmitting unit 546 and the data receiving unit 552. As previously mentioned, the data transmitting unit 546 and the data receiving unit 552 may communicate through wireless connection or wired connection. In other words, in terms of hardware configuration and data transmission, in one embodiment of the present invention, the nine-axis motion sensor module 502 comprising the rotation sensor 542, the accelerometer 544 and the magnetometer 545 may be disposed distally from the processing unit or computing processor 554; the signals from the nine-axis motion sensor module 502 may then be transmitted via the data transmitting units 546, 552 to the computing processor 554 via wired or wireless communication including for example IEEE 802.11 standards or Bluetooth™.

[0045] The second part 570 of the electronic device 500 according to one embodiment of the present invention comprises the data transmitting unit 552 and the processor 554. The data transmitting unit 552 of the second part 570 may be in data communication with the other data transmitting unit 546 disposed distally therefrom in the first part 560 as previously mentioned. The data transmitting unit 552 in the second part 570 receives the first, second and third signal sets from the data transmitting unit 546 in the first part 560 and transmits the first, second and third signal sets to the computing processor 554. In one embodiment, the computing processor 554

performs the aforementioned calculation as well as comparison of signals. In one embodiment, said comparison utilized by the computing processor 554 may further comprise an update program to obtain an updated state based on or from a previous state associated with said first signal set and a measured state associated with said second and third signal sets. The measured state may further include a measurement of said second and third signal sets and predicted measurements obtained based on the first signal set or based on a current state of the motion sensor module 502. The computing processor 554 is external to the housing of the 3D pointing device as depicted in Fig. 5. In one embodiment, the computing processor 554 also performs mapping by translating the resultant angles of the resulting deviation of the electronic device in the spatial pointer reference frame, preferably about each of three orthogonal coordinate axes of the spatial reference frame, to a movement pattern in a display reference frame associated with the notebook computer 580. The movement pattern may be displayed on the screen 582 of the notebook computer 580.

[0046] FIG. 6 is an exploded diagram showing a portable electronic device 600, such as for example a 3D pointing device, utilizing a nine-axis motion sensor module according to anther embodiment of the present invention in a 3D spatial reference frame. The portable electronic device 600 may further comprises a built-in display 682; examples of the portable electronic device 600 as an explanatory embodiment of the present invention may include such as smartphone, tablet PC or navigation equipment. In other words, the abovementioned display reference frame associated with a display may need not to be external to the spatial reference frame in terms of the hardware configuration of the present invention. In one embodiment, the electronic device 600 comprises a bottom cover 620, a PCB 640, a battery pack 622, a rotation sensor 642, an accelerometer 644, a magnetometer 645, a data transmitting unit 646, a computing processor 648,

a display 682, and a top cover 610. Likewise, in one embodiment, the housing 630 may comprise the top and bottom covers 610, 620. A built-in display 682 may too be integrated on the housing 630; the nine-axis motion sensor module 602 may comprise the rotation sensor 642, the accelerometer 644 and the magnetometer 645. The data transmitting unit 646 and the computing processor 648 may also be integrated as a processing and transmitting module 604 of the electronic device 600. In one embodiment of the present invention, the motion sensor module or nine-axis motion sensor module 602 of the portable electronic device 600 may refer to a MEMS type of sensor. In an explanatory example, the abovementioned rotation sensor 642 of the nine-axis motion sensor module 602 may further comprise at least one resonating mass such that a movement of said at least one resonating mass along an axis of said spatial reference frame may be detected and measured by said rotation sensor using the Coriolis acceleration effect to generate said first signal set comprising angular velocities ωx, ωy, ωz in said spatial reference frame. It can be understood that for a three-axis rotation sensor of a MEMS type sensor, there may be positioned three resonating masses along each of X, Y and Z axes of the spatial reference frame to generate and obtain movements or displacements of the three resonating masses thereof. It can too be understood that the nine-axis motion sensor 602 of the present invention may also include a three-axis accelerometer, a three-axis rotation sensor and a three-axis magnetometer in a MEMS structure.

[0047] The computing processor 648 of the processing and transmitting module 604 may too perform the mapping of resultant deviation from or in said spatial reference frame or 3D reference frame to a display reference frame such as a 2D reference frame by translating the resultant angles of the resulting deviation of the electronic device 600 in the spatial reference frame, preferably

about each of three orthogonal coordinate axes of the spatial reference frame to a movement pattern in a display reference frame associated with the electronic device 600 itself. The display 682 displays the aforementioned movement pattern. The top cover 610 includes a transparent area 614 for the user to see the display 682.

[0048] FIG. 7 is an explanatory flow chart illustrating a method for obtaining and/or outputting a resultant deviation including deviation angles in a spatial reference frame of an electronic device, including such as a pointing device, navigation equipment or smartphone, having movements and rotations in a 3D spatial reference frame and in dynamic environments according to an embodiment of the present invention. The method in Fig. 7 may be a program such as an algorithm or a comparison model to be embedded or performed by the processing unit or computing processor 348, 554, 648 of the processing and transmitting module according to different embodiments of the present invention recited herein for illustrative purposes.

[0049] Accordingly, in one embodiment of the present invention, a method for obtaining a resultant deviation including deviation angles in a spatial reference frame of an electronic device utilizing a nine-axis motion sensor module therein in dynamic environments and preferably excluding undesirable external interferences thereof is provided. As the electronic device may be subject to movements and rotations in the dynamic environments, undesirable interferences may cause the measurements, calculations or outputs of the motion sensor module thereof to be errorsome. In one embodiment, said method may comprise the following steps. First of all, as shown in FIG.7, different states including “previous state”, “current state”, “measured state” and “update state” of the nine-axis motion sensor module may be provided to represent a step or a set

of steps utilized by the method for obtaining the resulting deviation in 3D reference frame, and preferably in the abovementioned "absolute" manner. In one exemplary embodiment, the method comprises the steps of obtaining a previous state of the nine-axis motion sensor module (such as steps 705, 710); and wherein the previous state may too include an initial-value set predetermined to initialize said previous state of the nine-axis motion sensor module at a beginning of the method. The initial-value set may preferably be utilized at said beginning of the method or a start of the method where a previous state is not available to be obtained from an updated state (to be recited hereafter). In another embodiment where previous state may be obtained or updated from an updated state, said previous state may be a first quaternion inducing values associated with at least previous angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the nine-axis motion sensor module at a previous time T-1. A current state of the nine-axis motion sensor module may then be subsequently obtained by obtaining measured angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the nine-axis motion sensor module at a current time T (such as steps 715, 720). A measured state of the nine-axis motion sensor module may then be obtained by obtaining measured axial accelerations Ax, Ay, Az gained from the motion sensor signals of the nine-axis motion sensor module at the current time T (such as step 725). Furthermore, the step of calculating predicted axial accelerations Ax', Ay', Az' based on the measured angular velocities ω_x, ω_y, ω_z of the current state of the nine-axis motion sensor module (such as step 730); obtaining an updated state of the nine-axis motion sensor module by comparing the current state with the measured state of the nine-axis motion sensor module (such as step 735); and calculating and converting the updated state of the nine-axis motion sensor module to said resulting deviation comprising said resultant angles in said spatial reference frame of the electronic device (745) may then be performed and obtained; and whereby the resultant deviation comprising deviation angles

associated with the updated state of the nine-axis motion module may be obtained excluding said undesirable external interferences in the dynamic environments. In order to provide a continuous loop such as performed in a looped manner, the result of the updated state of the nine-axis motion sensor module may preferably be outputted to the previous state; in one embodiment, the updated state may be a quaternion, namely third quaternion as shown in the figure, such that it may be directly outputted to the abovementioned previous state of another quaternion, namely the abovementioned first quaternion and as shown in the figure (such as step 740).

[0050] In addition, it can be understood that the abovementioned comparison utilized by the processing and transmitting module and comprising the update program may too make reference to said different states of the nine-axis motion sensor module as shown in FIGs 7 and 8. As mentioned previously, the update program may be utilized by the processor to obtain the updated state of the nine-axis motion sensor module based on the previous state associated with a first signal set in relation to the angular velocities ω_x, ω_y, ω_z and the measured state associated with said second signal set in relation to the axial accelerations Ax, Ay, Az. The abovementioned measured state may include a measurement of said second signal set or measured Ax, Ay, Az and a predicted measurement of Ax', Ay' and Az' obtained based on or calculated from the first signal set. Details of each of the abovementioned states of the nine-axis motion sensor module and the related steps of the method for obtaining the resultant deviation of the electronic device in 3D reference frame are as follows.

[0051] Referring to FIG. 7 again, the method for obtaining a resultant deviation including resultant angles in a spatial reference frame of electronic device utilizing a nine-axis motion sensor

module according to one embodiment of the present invention may begin at the obtaining of a previous state of the nine-axis motion sensor module. In one embedment, the previous state of the nine-axis motion sensor module may preferably be in a form of a first quaternion, and the first quaternion may be preferably initialized (step 705) at a very beginning of the process or method and as part of the obtaining of the previous state thereof. In other words, according to one embodiment of the present invention, the signals of the nine-axis motion sensor are preferably to be initialized according to a predetermined value set or quaternion including such as zeros and in particular, the signal or value associated with the yaw angle in terms of a quaternion value. The four elements of the first quaternion may be initialized with predetermined initial values. Alternatively, the first quaternion may be initialized or replaced by another signal sets generated by the rotation sensor and the accelerometer at a next time frame such that the method as shown in Fig. 7 is a continuous loop between a previous time frame T-1 and a present time frame T; details on the replacement of the first quaternion at T-1 with the later outputted quaternion at T is to be provided in the later content. It can be understood that one may make reference to Euler Angles for definition on quaternion. Similarly, it can be easily comprehended that the abovementioned previous time T-1 and present time T may too be substitute by a present time T and a next time T+1 respectively and shall too fall within the scope and spirit of the present invention.

[0052] In addition, the abovementioned dynamic environments may include undesirable external interferences to the present invention as mentioned previously. For instance, the undesirable external interferences nay refer to or include undesirable axial accelerations caused by undesirable external forces other than a force of gravity and they may too include or refer to include

undesirable magnetism caused by undesirable electromagnetic fields. In a preferred embodiment of the present invention, one of the technical effects of the perform of the method as shown in FIG. 7 include that the abovementioned updated state of the nine-axis motion sensor module to said resulting deviation comprising said resultant angles in said spatial reference frame of the electronic device (step 745) may be preferably obtained excluding undesirable interferences in the dynamic environments, such as decoupling of undesirable external forces from the force of gravity to exclude undesirable axial accelerations and exclusion of undesirable external magnetism caused or induced by undesirable electromagnetic fields in the dynamic environments.

[0053] The method illustrated in Fig. 7 may be performed in consecutive time frames. According to one embodiment of the present invention, steps 710-745 may be performed in a looped manner by such as a data processing unit of an electronic device of the present invention. In another embodiment, multiple steps may be performed simultaneously, such as the obtaining of signals from the nine-axis motion sensor module may be performed simultaneously instead of one after another. It can therefore be understood that the steps recited herein are for illustrative purposes only and any other sequential orders or simultaneous steps are possible and shall too be considered to be within the scope of the present invention. The first quaternion with respect to the previous time T is obtained as shown in the figure as step 710. When step 710 is performed, the first quaternion initialized in step 705 is obtained. Otherwise, the first quaternion used in the present time T is generated in the previous time T-1. In other words, the step 710 may generally refer to or represented by the abovementioned "previous state" of the nine-axis motion sensor module; according to another embodiment, the previous state may refer to the steps of 705 and 710.

[0054] The next may be to obtain the first signal set generated by the rotation sensor, which includes the measured angular velocities ω_x, ω_y and ω_z as shown in step 715 according to an exemplary embodiment of the present invention. In step 720, the second quaternion with respect to a present time T is calculated and obtained based on the angular velocities ω_x, ω_y and ω_z. The step 715 and 720 may generally refer to or may be represented by the abovementioned "current state" of the nine-axis motion sensor module. In one embodiment, the computing processor may use a data conversion utility including such as an algorithm to convert the angular velocities ω_x, ω_y , ω_z and first quaternion into the second quaternion. This data conversion utility may be a program or instruction represented by the following equation (1).

$$\begin{bmatrix} \dot{q}_0 \\ \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \end{bmatrix} = \frac{1}{2} \begin{bmatrix} 0 & -\omega_x & -\omega_y & -\omega_z \\ \omega_x & 0 & \omega_z & -\omega_y \\ \omega_y & -\omega_z & 0 & \omega_x \\ \omega_z & \omega_y & -\omega_x & 0 \end{bmatrix} \begin{bmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{bmatrix} \quad \text{..... (1)}$$

Equation (1) is a differential equation. The quaternion on the left side of the equal sign is the first order derivative with respect to time of the quaternion (q_0, q_1, q_2, q_3) on the right side of the equal sign. The data conversion utility uses the first quaternion as the initial values for the differential equation (1) and calculates the solution of the differential equation (1). The second quaternion may be represented by a solution of the differential equation (1).

[0055] As shown in the figure, the "measured state" of the nine-axis motion sensor module according to one embodiment of the present invention may generally refer or may be represented by steps 725 and 730. In step 725, the second signal set generated by the accelerometer may be

obtained, which includes measured axial accelerations Ax, Ay and Az; or Ax, Ay and Az may refer to the measurement of the axial accelerations obtained. In order to obtain said measured state of the nine-axis motion sensor of the present invention, according to one embodiment, predicted axial accelerations Ax', Ay' and Az' may too be calculated and obtained based on the abovementioned current state of the nine-axis motion sensor module or the second quaternion as shown in step 730. In other words, two sets of axial accelerations may be obtained for the measured state of the nine-axis motion sensor module; one may be the measured axial accelerations Ax, Ay, Az in step 725 and the other may be the predicted axial accelerations Ax', Ay', Az' in step 730 calculated based on the abovementioned current state or second quaternion in relation to the measured angular velocities thereof. Furthermore, in one embodiment, the computing processor may use a data conversion utility to convert quaternion into the predicted axial accelerations Ax', Ay' and Az'. This data conversion utility may be a software program represented by the following equations (2), (3) and (4).

$$2(q_1q_3 - q_0q_2) = Ax' \quad \text{..... (2)}$$

$$2(q_2q_3 + q_0q_1) = Ay' \quad \text{..... (3)}$$

$$q_0^2 - q_1^2 - q_2^2 + q_3^2 = Az' \quad \text{..... (4)}$$

The computing processor calculates the solution (Ax', Ay', Az') of the equations (2), (3) and (4).

[0056] According to an exemplary embodiment of the method for obtaining a resultant deviation including deviation angles in a spatial reference frame of an electronic device, including such as a 3D pointing device, a portable electronic device, a navigation equipment or a smartphone, utilizing a nine-axis motion sensor module, it may be preferable to compare the current state of

the nine-axis motion sensor module with the measured state thereof with respect to the present time frame T by utilizing a comparison model. In other words, in one embodiment as shown in step 735, it is preferable to compare the second quaternion in relation to the measured angular velocities of the current state at present time T with the measured axial accelerations Ax, Ay, Az as well as the predicted axial accelerations Ax', Ay', Az' also at present time T. Following which, a result may be advantageously obtained as an updated state of the nine-axis motion sensor module, excluding the abovementioned undesirable external interferences of the dynamic environments. In an explanatory example, the updated state may generally refer to the update of the current state of the nine-axis motion sensor module at preset time T. Instructions including equations related to the abovementioned current state, measured state and updated state may be illustrated in the following.

[0057] According to an exemplary embodiment of the comparison model utilized by the present invention in relation to step 735 as shown in the figure, the current state correlated to the abovementioned second quaternion and in relation to the angular velocities of gyroscope(s) may be obtained based on an exemplary equation of:

$$x(t \mid t-1) = f(x_{t-1}, u_t) \quad \text{..... (5)}$$

Preferably, a first probability (state transition probability) associated with the said current state may be further obtained based on an exemplary equation of:

$$P(x_t \mid x_{t-1}, u_t) = F_x P(x_{t-1} \mid x_{t-1}) F_x^{\ T} + F_u P(u_{t-1} \mid u_{t-1}) F_u^{\ T} + Q_t$$

$$F_x = \frac{\partial f(x_{t-1}, u_t)}{\partial x_{t-1}} \quad \text{..... (6)}$$

$$F_u = \frac{\partial f(x_{t-1}, u_t)}{\partial u_t} \quad \text{..... (7)}$$

wherein Q_t = addtional motion model noise

Likewise, the measured state correlated to the abovementioned predicted axial accelerations and in relation to the axial accelerations of accelerometers and current state may be obtained based on an exemplary equation of:

$$z_t(t \mid t-1) = h(x(t \mid t-1)) \quad \text{..... (8)}$$

Preferably, a second probability (measurement probability) associated with the measured state may be further obtained based on an exemplary equation of:

$$P(z_t \mid x_t) = H_x P(x_t \mid x_{t-1}) H_x^{\ T} + R_t \quad \text{..... (9)}$$

$$H_x = \frac{\partial h(x(t \mid t-1))}{\partial x(t \mid t-1)} \quad \text{..... (10)}$$

wherein R_t = measurement model noise

As an illustrative example, the abovementioned first and second probabilities may be further utilized to obtain the updated state of the nine-axis motion sensor module based on an exemplary method of data association of an exemplary equation of:

$$D_t = \{[z_t - h(x(t \mid t-1))] P(z_t \mid x_t) [z_t - h(x(t \mid t-1))]^{-1}\}^{1/2} \quad \text{..... (11)}$$

In one embodiment, the result of the updated state of the nine-axis motion sensor module, preferably involving comparison or data association represented by the equations, may be a third quaternion as shown in the figure. Furthermore, the result may then be further outputted and utilized to obtain a resultant deviation, excluding undesirable interferences of the dynamic environments under which the present invention is subject to, but including deviation angles in a spatial reference frame in the following steps as shown in the figure. In a preferred embodiment of the present invention, said undesirable external interferences may further comprise or refer to undesirable axial accelerations caused by undesirable external forces other than a force of gravity;

in another preferred embodiment, said undesirable external interferences may further comprise or refer to undesirable magnetism caused by undesirable electromagnetic fields. In other words, the method and algorithm provided by the present invention may preferably generate or provide an output of the resultant deviation of the nine-axis motion sensor module excluding the abovementioned undesirable interferences. In one example, external forces exerted to cause axial accelerations of a nine-axis motion sensor of an electronic device of the present invention may be decoupled or separated from a force of gravity; and in another example, the undesirable magnetism caused by such as electromagnetic fields external or internal to an electronic device the present invention may be excluded. It can be understood that the examples of current state, measured state, state update, data association and probabilities of the comparison model and method of the present invention recited herein are provided for illustrative purposes only.

[0058] As mentioned previously, it may be preferable to output the result of the updated state, preferably in a form of third quaternion, to the previous state of the nine-axis motion sensor module as shown in step 740 in FIG.7. In a preferred embodiment, the updated state may further comprise a first data association model; and wherein the abovementioned and related data association model may be provided for comparing the measured state associated with said second signal set with a predicted measurement obtained from said current state. In other words, in one embodiment, the first quaternion may be replaced by the abovementioned third quaternion or substitute directly any previous values of first quaternion in the previous time T for further process in a loop. In other words, the third quaternion with respect to the present time T becomes the first quaternion with respect to the next time such as T+1; or, the third quaternion at previous time frame T-1 outputted may now be the first quaternion at present time frame T.

[0059] In step 745, the updated state of the nine-axis motion sensor module of the present invention may be further calculated and converted to the resultant deviation including deviation angles associated with the spatial reference frame, wherein the deviation angles includes the yaw angle, pitch angle and roll angle of the electronic device associated with the spatial reference frame, preferably about each of three orthogonal coordinate axes of the spatial reference frame; and whereby the resultant deviation comprising deviation angles associated with the updated state of the nine-axis motion module may be preferably obtained excluding said undesirable external interferences in the dynamic environments. In an explanatory example, said undesirable external interferences may refer to or further comprise undesirable axial accelerations caused by undesirable external forces other than a force of gravity. In another explanatory example, said undesirable external interferences may refer to or further comprise undesirable magnetism caused by undesirable electromagnetic fields. In one embodiment, the computing processor may use a data conversion utility to convert the third quaternion of the updated state of the nine-axis motion sensor module into the yaw, pitch and roll angles thereof. This data conversion utility may be a program or instruction represented by the following equations (12), (13) and (14).

$$yaw = \arctan\left(\frac{2(q_0q_3 + q_1q_2)}{q_0^2 + q_1^2 - q_2^2 - q_3^2}\right) \quad \text{..... (12)}$$

$$pitch = \arcsin(2(q_0q_2 - q_3q_1)) \quad \text{..... (13)}$$

$$roll = \arctan\left(\frac{2(q_0q_1 + q_2q_3)}{q_0^2 - q_1^2 - q_2^2 + q_3^2}\right) \quad \text{..... (14)}$$

The variables q_0, q_1, q_2 and q_3 in equations (12), (13) and (14) are the four elements of the third quaternion.

[0060] For a looped method continuous with respect to time, in one embodiment of the present invention, the method utilized by for example the computing processor communicated with the nine-axis motion sensor module may return to step 710 to perform the comparison process or method with respect to the next time T+1. In addition, the abovementioned resultant deviation including deviation angles comprising yaw, pitch and roll angles in the spatial reference frame converted from the third quaternion is preferably obtained and outputted in an absolute manner reflecting or associating with the actual movements and rotations of the electronic device of the present invention in said spatial reference frame. It can be understood that said actual movements and rotations of the electronic device of the present invention in the spatial reference frame or 3D reference frame may refer to real-time movements and rotations associated with vectors having both magnitudes and directions along or about orthogonal axes in the spatial reference frame under the dynamic environments.

[0061] FIG. 8 shows a flow chart illustrating a method of mapping resultant deviation angles of an electronic device having movements and rotations in a 3D spatial reference frame and in a dynamic environment onto a display reference frame according to another embodiment of the present invention. FIG. 9 is a schematic diagram showing the aforementioned mapping of the resultant angles of the resultant deviation of an electronic device according to this embodiment. For illustrative purposes, the difference between FIG. 7 and Fig. 8 may be represented by the additional mapping step 750 as shown in FIG. 8. Steps 705-745 in Fig. 8 are the same as their counterparts in Fig. 7, which perform the comparison process for the 3D pointing device. Step 750 performs the mapping process for the electronic device. The computing processor may include a

mapping program that performs the mapping step 750. At step 750, the processing and transmitting module may obtain display data including for example, display screen size such as boundary information, and translates the deviation angles of the resultant deviation associated with the spatial reference frame, preferably about each of three orthogonal coordinate axes of the spatial reference frame, to a movement pattern in a mapping area in a display reference frame based on a sensitivity input correlated to the display reference frame. It can be understood that the abovementioned display data may too include or refer to the type of display such as LED, LCD, touch panel or 3D display as well as frequency rate of display such as 120Hz or 240Hz. In one embodiment, the display reference frame associated with the display to be mapped may be a 2D display reference frame; in another embodiment, the display reference frame may be a 3D display reference frame of a 3D display.

[0062] The aforementioned display data may further include a sensitivity input. The aforementioned sensitivity input is a parameter which may be inputted and adjusted by a user through control buttons attached on the housing of the electronic device. The sensitivity input may represent the sensitivity of the display device with respect to the movement of the electronic device. For details of the mapping process, please refer to Fig. 9. In one embodiment, the sensitivity input is a parameter representing the relationship between the display to be mapped with deviation to a movement pattern in 2D display reference frame and the electronic device of the present invention outputted with said deviation including yaw, pitch and roll angles in 3D reference frame; wherein the relationship may be a distance relationship. In another embodiment, the sensitivity input may be a display screen size including boundary information predetermined by a user; wherein the boundary information may be obtained based on a user input or manual input data from the user.

In still another embodiment, the sensitivity input may be predefined or preset in the mapping program such that the parameter of the sensitivity input is a preset value for either increase or decrease the movement patterns including distance or number of pixels to be moved or mapped from said resultant deviation of the electronic device of the present invention.

[0063] Fig. 9 is a bird's-eye view of an electronic device 930 according to one embodiment of the present invention directed to a display screen 910 of a display device. The display screen has a central point 922, a target point 924 and a boundary point 926. The central point 922 is the geometric center of the display screen 910. The target point 924 is the position that the electronic device 930 is aiming at. The boundary point 926 is a point on the right boundary of the display screen 910. The points 922, 924, 926 and the electronic device 930 are on a common plane parallel to both the X_D axis and the Z_D axis of the display reference frame $X_DY_DZ_D$. Virtual beams 942, 944 and 946 are imaginary light beams from the electronic device 930 to the central point 922, the target point 924 and the boundary point 926, respectively. The distance P is the distance between the central point 922 and the target point 924, while the distance P_{max} is the distance between the central point 922 and the boundary point 926. The distance d is the distance between the central point 922 and the electronic device 930. The aforementioned yaw angle of the resultant deviation of the electronic device 930 of the present invention is the angle θ between the virtual beams 942 and 944, while the angle θ_{max} is the angle between the virtual beams 942 and 946. The aforementioned mapping area is a plane including the display surface of the display screen 910 in the display reference frame. The display surface of the display screen 910 is a subset of the mapping area.

[0064] In this embodiment, the aforementioned sensitivity input is provided by the user of the electronic device 930. The sensitivity β is defined by the following equation (15).

$$\beta = \frac{P_{\max}}{\theta_{\max}} \quad \text{..... (15)}$$

The variable β in equation (16) is the sensitivity input defined by user.

The following equation (16) may be derived from equation (15) and geometry.

$$d = \frac{P_{\max}}{\tan\left(\frac{P_{\max}}{\beta}\right)} \quad \text{.....(16)}$$

The following equation (17) may be derived from equations (16).

$$P = f(\theta) = d \times \tan\theta = \frac{P_{\max} \times \tan\theta}{\tan\left(\frac{P_{\max}}{\beta}\right)} \quad \text{.....(17)}$$

[0065] In equation (17), the distance P_{max} may be obtained from the width of the display screen of the display data obtained at step 750; the angle θ is the yaw angle obtained at step 745; the sensitivity input β is provided by the user. Therefore, the computing processor of the electronic device 930 can calculate the distance P according to equation (17). Next, the computing processor can easily obtain the horizontal coordinate of the target point 924 on the display screen 910 according to the distance P and the width of the display screen 910. In addition, the computing processor can easily obtains the vertical coordinate of the target point 924 on the display screen 910 according to the pitch angle in a similar way.

[0066] The mapping process performed at step 750 may be exemplified by the process of translating the yaw angle and the pitch angle of the resultant angles to the 2D coordinates of the target point 924 on the display screen 910 discussed above. Now the computing processor has the coordinates of the target point 924 of the present time frame. The computing processor subtracts the coordinates of the target point 924 of the previous time frame from the coordinates of the target point 924 of the present time frame. The result of the subtraction is the horizontal offset and the vertical offset of the target point 924 in the present time frame. The horizontal and vertical offsets may be transmitted to the display device so that the display device can track the position of the target point 924. The display device may display a cursor or some video effect on the display screen 910 to highlight the position of the target point 924. The cursor or video effect may exhibit a movement pattern on the display screen 910 when the user moves the electronic device 930 of the present invention.

[0067] Likewise, according to another embodiment of the present invention, the comparison method of the present invention may be a lopped method. For a looped method continuous with respect to time, in one embodiment, the method utilized by for example the computing processor communicating with the nine-axis motion sensor module may return to step 710 to perform the comparison process or method with respect to the next time T+1, following which the comparison and mapping process with respect to the next time frame may then be performed.

[0068] FIG. 10 shows another embodiment of the comparison method of the present invention. The flow chart illustrates a method of obtaining resultant deviation including deviation angles in a spatial reference frame of an electronic device utilizing a nine-axis motion sensor module therein

and subject to movements and rotations in dynamic environments in the spatial reference frame and mapping resultant deviation of the electronic device of the present invention having movements and rotations in a 3D spatial reference frame and in a dynamic environment onto a display reference frame according to another embodiment of the present invention; and whereby the resultant deviation comprising deviation angles associated an output or state such as an updated state (details below) of the nine-axis motion module may be preferably obtained excluding said undesirable external interferences in the dynamic environments. In an explanatory example, said undesirable external interferences may refer to or further comprise undesirable axial accelerations caused by undesirable external forces other than a force of gravity. In another explanatory example, said undesirable external interferences may refer to or further comprise undesirable magnetism caused by undesirable electromagnetic fields. The steps 1005-1030 in Fig. 10 may make reference to the ones shown in another embodiment of the present invention as shown in Fig. 7.

[0069] For an electronic device, including such as a pointing device, a navigation equipment, a smartphone or other portable electronic apparatus, utilizing a nine-axis motion sensor module, the signals of the magnetometer of the motion sensor module may be preferably be used to facilitate the obtaining of the resultant deviation including deviation angles in 3D reference and preferably in an absolute manner. The third signal set generated by the magnetometer may be obtained as shown in step 1035 in FIG. 10, which includes measured magnetism Mx, My and Mz. In one embodiment, the Mx, My and Mz may refer to the measurement of the magnetism obtained. In order to obtain said measured state of the nine-axis motion sensor, according to one embodiment of the present invention, predicted magnetism Mx', My' and Mz' may too be calculated and obtained based on the abovementioned current state of the nine-axis motion sensor module or the

second quaternion as shown in step 1040. In other words, two sets of magnetism may be obtained for the measured state of the nine-axis motion sensor module; one may be the measured magnetism Mx, My, Mz in step 1035 and the other may be the predicted magnetism Mx', My', Mz' in step 1040 calculated based on the abovementioned current state or second quaternion in relation to the measured angular velocities thereof. Furthermore, in one embodiment, the computing processor may use a data conversion utility to convert the current state or second quaternion into predicted magnetism Mx',My' and Mz' and vice versa. This data conversion utility may be a software program represented by the following equations (18), (19) and (20).

$$(q_0^{\ 2} + q_1^{\ 2} - q_2^{\ 2} - q_3^{\ 2})\cos\lambda + 2(q_1q_3 - q_0q_2)\sin\lambda = Mx' \quad \text{..... (18)}$$

$$2(q_1q_2 - q_0q_3)\cos\lambda + 2(q_2q_3 + q_0q_1)\sin\lambda = My' \quad \text{..... (19)}$$

$$2(q_1q_3 + q_0q_2)\cos\lambda + (q_0^2 - q_1^2 - q_2^2 + q_3^2)\sin\lambda = Mz' \quad \text{..... (20)}$$

The variable λ in equations (18), (19) and (20) is the dip angle between the direction of the ambient magnetic field measured by the magnetometer and a horizontal plane in the spatial reference frame. The dip angle λ may be measured or calculated through an initial calibration process of the electronic device of the present invention and then be used as a parameter. The computing processor calculates the solution (Mx',My',Mz') of the equations (18), (19) and (20).

[0070] According to an exemplary embodiment of the method for obtaining a resultant deviation including deviation angles in a spatial reference frame of an electronic device, including such as a pointing device, a navigation equipment, a smartphone or other portable electronic apparatus, utilizing a nine-axis motion sensor module, it may be preferable to compare the current state of the nine-axis motion sensor module with the measured state thereof with respect to the

present time frame T by utilizing a comparison model. In other words, in one embodiment as shown in step 1045, it is preferable to compare the second quaternion in relation to the measured angular velocities of the current state at present time T with the measured axial accelerations Ax, Ay, Az, the predicted axial accelerations Ax', Ay', Az', the measured magnetism Mx, My, Mz, and the predicted magnetism Mx', My', Mz' also at present time T. Following which, a result may be obtained as an updated state of the nine-axis motion sensor module. In general and in an explanatory example of the present invention, the updated state may generally refer to the update of the previous state of the nine-axis motion sensor module at a previous time T-1 with reference to the current state and/or measured state thereof. The comparison model in step 1045 utilizes the measured axial accelerations Ax, Ay, Az and measured magnetism Mx, My, Mz, as well as the predicted axial accelerations Ax', Ay', Az' and the predicted magnetism Mx', My', Mz'.

[0071] In one embodiment, the result of the updated state of the nine-axis motion sensor module, preferably involving comparison or data association represented by the equations associated to the comparison model, may be a third quaternion as shown in the figure. Furthermore, as shown in steps 1050~1060, the result may then be further outputted and utilized to obtain a resultant deviation including deviation angles in a spatial reference frame in the steps as shown in the figure. It can be understood that the examples of current state, measured state, state update, data association and probabilities of the comparison model and method of the present invention are provided for illustrative purposes only.

[0072] FIG. 11 shows a further exemplary embodiment of the comparison method of the present invention. The flow chart illustrates a method of obtaining resulting deviation including resultant

angles in a spatial reference frame of an electronic device, including such as a pointing device, a navigation equipment, a smartphone or other portable electronic device, utilizing a nine-axis motion sensor module therein and subject to movements and rotations in dynamic environments in the spatial reference frame and mapping resultant deviation angles of said electronic device having movements and rotations in the 3D spatial reference frame and in a dynamic environment onto a display reference frame according to another embodiment of the present invention. Likewise, steps 1105~1130 may include obtaining a previous state and a current state of the motion sensor module as well as a measured state related to the axial accelerations of the motion sensor module. Additionally, in step 1135, it may be preferable to compare the current state of the nine-axis motion sensor module with the measured state thereof with respect to the present time frame T by utilizing a comparison model. In other words, as shown in step 1135, it is preferable to compare the second quaternion in relation to the measured angular velocities of the current state at present time T with the measured axial accelerations Ax, Ay, Az as well as the predicted axial accelerations Ax', Ay', Az' also at present time T. Following which, a result may be obtained as the first updated state of the nine-axis motion sensor module. In an explanatory example, the first updated state may generally refer to the first update of the current state of the nine-axis motion sensor module at preset time T. Furthermore, one of the technical effects of the present invention may too be obtained or achieved. In step 1135, one of the advantages or effects by performing steps from1105~1135 may be that the first updated state or third quaternion as shown in FIG. 11 may be advantageously obtained excluding undesirable axial accelerations caused by for example undesirable external forces such as the ones decoupled from a force of gravity.

[0073] In one embodiment, the result of the first updated state of the nine-axis motion sensor

module, preferably involving comparison or data association represented by the equations associated to the comparison model, may be a third quaternion as shown in the figure. In addition, one of the technical effects of the present invention may include the exclusion of undesirable external interferences in the dynamic environment as previously mentioned; and wherein the undesirable external interferences may refer to or further include undesirable axial accelerations caused by undesirable external forces, preferably decoupled from a force of gravity, and/or undesirable magnetism caused by for example undesirable electromagnetic fields either adjacent to the motion sensor module. As shown in step 1140 of FIG. 11, the first updated state of the nine-axis motion sensor module of the present invention may be further calculated and converted to a temporary pitch angle and a temporary roll angle based on the third quaternion. The first updated state, as shown in the figure, may be advantageously obtained such that or whereby undesirable axial accelerations associated with said undesirable external interferences in the dynamic environments may be preferably excluded; in an explanatory example, the first updated state may be preferably obtained excluding the abovementioned undesirable axial accelerations caused by undesirable external forces, such as external forces decoupled from a force of gravity. The third signal set generated by the magnetometer may be obtained, which includes measured magnetism Mx, My and Mz. The measured state of the nine-axis motion sensor module may be obtained by obtaining and calculating a measured yaw angle gained from the motion sensor signals of the nine-axis motion sensor module at the current time T according to the following equation (21).

$$Ty = \frac{-My\cos(Tr) + Mz\sin(Tr)}{Mx\cos(Tp) + My\sin(Tp)\cos(Tr) + Mz\sin(Tp)\cos(Tr)} \quad \text{..... (21)}$$

In equation (21), Ty is the measured yaw angle, Tp is the temporary pitch angle and Tr is the temporary roll angle.

[0074] In order to obtain said measured state of the nine-axis motion sensor, according to one embodiment of the present invention, a predicted yaw angle may be calculated and obtained based on the abovementioned first updated state of the nine-axis motion sensor module or the third quaternion at present time T as shown in step 1145. In other words, the measured yaw angle in step 1140 and the predicted yaw angle in step 1145 may be obtained for the measured state of the nine-axis motion sensor module.

[0075] Furthermore, it may be preferable to compare the current state of the nine-axis motion sensor module with the measured state thereof with respect to the present time frame T by utilizing a comparison model. In other words, as shown in step 1150, it is preferable to compare the second quaternion in relation to the measured angular velocities of the current state at present time T with the measured axial accelerations Ax, Ay, Az, the predicted axial accelerations Ax', Ay', Az', the measured yaw angle and the predicted yaw angle also at present time T. Following which, a result may be obtained as the second updated state of the nine-axis motion sensor module. In an explanatory example, the second updated state may generally refer to the second update of the current state of the nine-axis motion sensor module at preset time T. The comparison model in step 1150 is very similar to the abovementioned comparison models. Related details are omitted here for brevity. In one embodiment, the result of the second updated state of the nine-axis motion sensor module may be a fourth quaternion as shown in the figure. Furthermore, the result may then be further outputted and utilized to obtain a resulting deviation including resultant angles in a spatial reference frame in the following steps as shown in the figure. In addition to the abovementioned technical effects of the present invention in which undesirable axial accelerations

of undesirable external interferences in the dynamic environments may be advantageously excluded as a result of the first updated state of the motion sensor module in step 1135, another technical effect or merit may too be obtained along with result of the second updated state of the motion sensor as shown in step 1150 of FIG. 11. One of the advantages or effects by performing steps such as from 1140~1150 may be that the second updated state or fourth quaternion as shown in FIG. 11 may be advantageously obtained excluding undesirable magnetism such as the ones caused by for example undesirable external or internal electromagnetic fields adjacent to the motion sensor module in the dynamic environments of the present invention.

[0076] It may be preferable to output the result of the second updated state, preferably in a form of the fourth quaternion, to the previous state of the nine-axis motion sensor module as shown in step 1155 in the figure. In other words, in one embodiment, the first quaternion may be replaced by the abovementioned fourth quaternion or substitute directly any previous values of first quaternion in the previous time T for further process in a loop. In other words, the fourth quaternion with respect to the present time T becomes the first quaternion with respect to the next time such as T+1; or, the fourth quaternion at previous time frame T-1 outputted may now be the first quaternion at present time frame T.

[0077] In step 1160, the second updated state of the nine-axis motion sensor module of the present invention may be further calculated and converted to the resulting deviation including resultant angles associated with the spatial reference frame, wherein the resultant angles includes the yaw angle, pitch angle and roll angle of the 3D pointing device associated with the spatial reference frame, preferably about each of three orthogonal coordinate axes of the spatial reference

frame. In addition, the second updated state, as shown in the figure, may be advantageously obtained such that or whereby undesirable magnetism associated with said undesirable external interferences in the dynamic environments may be preferably excluded; in an explanatory example, the second updated state may be preferably obtained excluding the abovementioned undesirable magnetism caused by for example undesirable electromagnetic fields, or magnetism other than the planetary geomagnetism, adjacent or of a magnitude influencing magnetometer of the motion sensor module. The resultant angles may be calculated according to equations (12), (13) and (14), wherein the variables q_0, q_1, q_2 and q_3 in equations (12), (13) and (14) are the four elements of the fourth quaternion. Furthermore, the resultant deviation in step 1160 may be advantageously obtained excluding undesirable interferences including such as the ones of undesirable axial accelerations caused by undesirable external forces decoupled from a force of gravity mentioned previously in step 1135 and the ones of undesirable magnetism caused by for example undesirable electromagnetic fields as mentioned previously in step 1150. Likewise, in step 1165 as shown in FIG. 11, the resultant deviation including deviation angles in 3D pointer reference may be further mapped to a display reference such as a 2D display reference of a display.

[0078] As illustrated by FIG.12, in one preferred embodiment, the first and second updated states may further comprise a first data association model and a second data association model respectively. The first data association model may be advantageously provided for comparing the first measured state associated with said second signal set with a first predicted measurement obtained from said current state; in addition, the second data association model may too be advantageously provided for comparing the second measured state associated with said third signal set with a second predicted measurement obtained from said first updated state. Furthermore, in

another preferred embodiment, the first and second updated states may further comprise a first data association model and a second data association model respectively; and wherein the first data association model may be advantageously provided for comparing the first measured state associated with said second signal set with a first predicted measurement obtained from said current state; and wherein the second data association model may be advantageously provided for comparing the second measured state associated with said third signal set with a second predicted measurement obtained from said current state. Details on the differences of the obtaining of said second predicted measurement based on either the first updated state or the current state of the motion sensor module depending upon a comparison result are further described in FIG. 12, as the routes presented or denoted by "Yes" and "No' shown therein.

[0079] FIG. 12 shows an exemplary flow chart of another embodiment of the present invention of a method for obtaining a resultant deviation comprising deviation angles of an electronic device, including such as a pointing device, navigation equipment, a smartphone or other portable electronic apparatus. Accordingly, the method for obtaining a resultant deviation including deviation angles in a spatial reference frame of an electronic device utilizing a nine-axis motion sensor module therein and subject to movements and rotations in dynamic environments in said spatial reference frame includes the following steps. As shown in the figure, at step 1210, a previous state of the nine-axis motion sensor module may be obtained; and wherein the previous state is associated with at least previous angular velocities gained from the motion sensor signals of the nine-axis motion sensor module at a previous time T-1. In another embodiment, the previous state is associated with previous angular velocities, previous axial accelerations and previous magnetism gained from the motion sensor signals of the nine-axis motion sensor module at a

previous time T-1. Next, at step 1220, it may be to obtain a current state of the nine-axis motion sensor module by obtaining measured angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the nine-axis motion sensor module at a current time T. At step 1225, it may be to obtain a first measured state of the nine-axis motion sensor module by obtaining measured axial accelerations Ax, Ay, Az gained from the motion sensor signals of the nine-axis motion sensor module at the current time T. Following which and at step 1230 is calculating and obtaining a first predicted measurement of the nine-axis motion sensor module based on said current state thereof. At step 1235, a comparison may be performed to determine whether the signals related to the measured state including such as measured axial accelerations and/or measured magnetism are "good enough" to be used to compensate the current state of the motion sensor module and therefore an updated state thereof can be obtained.

[0080] According to the previously mentioned objectives of the present invention, it is preferable to provide an advantageous comparison or compensation method capable of outputting resultant deviation of a motion sensor module of a relatively high accuracy in the presence of external or internal interferences including such as electromagnetic fields generated by other electronic components adjacent to the motion sensor modules or of a magnitude strong enough to distort or affect the normal operations or signals of motion sensor module. Under such circumstances, a comparison utilizing data association may be advantageously provided or used to compare measured state of the motion sensor modules with an expected or predicted measurement thereof to determine the compensation for updating an updated state of the previous state. In step 1235 as previously mentioned, the data association may also include a predetermined value preset or preselected in accordance with for example the performance of motion sensor module utilized,

and such that the comparison result of the measured state and the predicted measurement may make reference to the data association and the predetermined value or range to determine the compensation needed to take place to update the state of the motion sensor module including such as the previous and/or current states thereof.

[0081] Accordingly, updated state(s) of the motion sensor module may be obtained based on the result of the data association(s). As shown in the figure, if the result of abovementioned comparison falls within the predetermined result of for example a predetermined value or range of the data association, then in one embodiment of the present invention, in step 1240, a first updated state of the nine-axis motion sensor module may be obtained based on a first comparison between said first predicted measurement and said first measured state of the nine-axis motion sensor module. Otherwise, if the result is not within the predetermined value of range of the data association, then the first updated state may not be performed or obtained. Such method of the use of data association and comparison may be particularly useful in the abovementioned scenario of external or internal "interferences" such as the ones caused by undesired electromagnetic fields. In the case where the result falls outside of expected range, or denoted by "No" as shown in FIG. 12, the next step would be to obtain another measured state or the second measured state of the motion sensor module to determine whether another data association may be utilized to obtain the second updated state. It can however be understood that the second updated state may be provided as an additional step to the method of the present invention. One may only perform the abovementioned steps and obtain a result of the first updated state based on the measured state including the measured axial accelerations associated with the motion sensor module; in other words, either performing steps to obtain only the first updated state, steps to obtain only the second

updated state, and/or steps to obtain both the first and second updated states as shown in the figure, shall all be considered to be within the scope of the present invention and within the spirit of the present invention. Furthermore and likewise, one of the technical effects of the present invention may too be obtained or achieved. In step 1240, one of the advantages or effects by performing steps from 1210~1240 may be that the first updated state as shown in FIG. 12 may be advantageously obtained excluding undesirable axial accelerations caused by for example undesirable external forces such as the ones decoupled from a force of gravity.

[0082] In another embodiment of the present invention or in the case where the abovementioned second updated state is to be obtained, one may further perform steps 1245 ~1260 as shown in FIG. 12. In step 1245, one may obtain a second measured state of the nine-axis motion sensor module by obtaining a measured yaw angle based on measured magnetism Mx, My, Mz gained from the motion sensor signals of the nine-axis motion sensor module at the current time T. Furthermore, as shown in step 1250, a second predicted measurement of the nine-axis motion sensor module may be calculated and obtained, following which a predicted yaw angle may too be obtained based on said first updated state thereof depending upon the result of the comparison such as the route denoted by "Yes" in FIG. 12. In another embodiment, the predicted yaw angle may be obtained based on said current state of the motion sensor module depending upon the result of the comparison such as a result or route of "No" denoted in FIG. 12. Once the measured state and the predicted measurements are obtained and available, a second comparison may be performed to determine whether compensation may be carried out based on the result of the comparison and the second data association. As shown in step 1255, the second data association including a predetermined value or range may be performed to determine whether the comparison

falls within said predetermined value or range. If the result falls within said value or range, then a second updated state may be obtained and compensation may too take place as shown in step 1260 with the denotation of "Yes". Otherwise, if the result is not within the predetermined value, then step 1265 shall be carried out, following the direction shown and denoted by "No" in the figure; and in other words, compensation may utilize the second predicted measurement of the motion sensor module thereof for updating instead of using the second measured state thereof. Likewise, in addition to the abovementioned technical effects of the present invention in which undesirable axial accelerations of undesirable external interferences in the dynamic environments may be advantageously excluded as a result of the first updated state of the motion sensor module in step 1240, another technical effect or merit may too be obtained along with result of the second updated state of the motion sensor as shown in step 1260 of FIG. 12. One of the advantages or effects by performing steps such as from 1245~1260 may be that the second updated state as shown in FIG. 12 may be advantageously obtained excluding undesirable magnetism such as the ones caused by for example undesirable external or internal electromagnetic fields adjacent to the motion sensor module in the dynamic environments of the present invention.

[0083] Following the above steps, in one embodiment of the present invention in which said comparison method may be provided in a continuous loop or a looped manner with respect to time, the result of the updated state at present time T may then be outputted to the previous state at previous time T-1 and become another beginning of the loop for the abovementioned steps to carry out again. The terminology of time(s) T, T-1 or T+1 shall be clear and apparent and shall too fall within the scope and spirit of the present invention. For example, in step 1260 as shown in FIG. 12, the second updated state of the nine-axis motion sensor module may be obtained by, or may

too include, the updating said first updated state thereof based on a second comparison between said second predicted measurement and said second measured state of the nine-axis motion sensor module; and in step 1265, the result of the second updated state thereof may be further outputted to the previous state in a looped manner with respect to time.

[0084] After step 1265, the resultant deviation including the deviation angles in the spatial reference frame, namely the yaw, pitch and roll angles, may be obtained in step 1270 in a similar way as those in steps 745, 1060 and 1160. Furthermore, the resultant deviation in step 1270 may be advantageously obtained excluding undesirable interferences including such as the ones of undesirable axial accelerations caused by undesirable external forces decoupled from a force of gravity mentioned previously in step 1240 and the ones of undesirable magnetism caused by for example undesirable electromagnetic fields as mentioned previously in step 1260.

[0085] As mentioned previously, in one embodiment of the present invention, the method for obtaining a resultant deviation of an electronic device utilizing a nine-axis motion sensor module, data associations may be provided to obtain a relatively accurate result under for example the existence of external or internal interferences to the sensor module. Accordingly, the abovementioned step of obtaining the first updated state of the nine-axis motion sensor module may further comprise performing a first data association to determine whether said first comparison between said first predicted measurement and said first measured state thereof falls within a first predetermined value of the nine-axis motion sensor module; and wherein the step of obtaining the second updated state of the nine-axis motion sensor module may too further comprise performing a second data association to determine whether said second comparison between said

second predicted measurement and said second measured state thereof falls within a second predetermined value of the nine-axis motion sensor module.

[0086] Likewise, in accordance to the abovementioned continuous loop of the method of the present invention with respect to time and in one embodiment, the method for obtaining a resultant deviation of an electronic device utilizing a nine-axis motion sensor module may further comprise outputting said second updated state of the nine-axis motion sensor module to said previous state thereof; and wherein said previous state of the nine-axis motion sensor module may be a first quaternion with respect to said previous time T-1; and wherein said current state of the nine-axis motion sensor module may be a second quaternion with respect to said current time T; and wherein said first and second updated states of the nine-axis motion sensor module may too be a third and a fourth quaternion with respect to said current time T respectively.

[0087] In summary, the present invention also provides a nine-axis comparison method that compares the detected signals generated by and converted from the rotation of the electronic device, utilizing a nine-axis motion sensor module, about all of the three axes with the detected signals generated by and converted from the acceleration of the device along all of the three axes. In one embodiment, The nine-axis comparison method may then output the resultant deviation including yaw, pitch and roll angles in a spatial reference frame such as a 3D reference frame of the device. In another embodiment, the nine-axis comparison method may also include the mapping of the resultant deviation including yaw, pitch and roll angles in the spatial reference to a display reference frame such as a 2D display reference frame of a display screen of a display device. The nine-axis comparison method involving the comparison of different states of the motion sensor

module and the utilization of data association of the present invention in order to output a resultant deviation having yaw, pitch and roll angles in for example 3D reference frame is novel and cannot be easily achieved by any know arts or their combinations thereof.

[0088] In view of the above, it is clear that such obtaining and outputting of deviation including 3D angles in a spatial reference frame in an "absolute" manner of the present invention is too novel, and the fact that the electronic device utilizing a motion sensor module therein having a novel comparison method and program of the present invention to obtain and output such deviation in "absolute" manner cannot be easily achieved by any known arts or their combination thereof. The term "absolute" associated with the resulting deviation including resultant angles such as yaw, pitch and roll in a spatial reference frame or 3D reference frame obtained and outputted by the device of the present invention may refer to the "actual" movements and rotations of the 3D pointer device of the present invention in said spatial reference frame. Moreover, the nine-axis comparison method of the present invention may accurately output said deviation including angles in 3D reference frame as noises associated with the nine-axis motion sensor module subject to movement and rotations in dynamic environments and accumulated over time may be effectively eliminated or compensated. Furthermore, the term "a", "an" or "one" recited herein as well as in the claims hereafter may refer to and include the meaning of "at least one" or "more than one". It can be understood that, as previously mentioned, the term of "dynamic" recited herein may refer to moving or subject to motions in general. It too can be understood that the term "excluding" recited herein to describe the exclusion of undesirable interferences is provided for illustrative purposes and shall not be limited to a certain or specific degree or magnitude of the effect of exclusion; any degree or magnitude associated thereto shall be considered to be within the spirit and scope of the

present invention. It may be understood that the present invention may be applied to various scenarios and application fields including such as gaming, computers and navigation. It may too be understood that the scope of the present invention shall be determined by the accompanying claims and shall include variations of applications of the present invention as well as differences in the term definitions used or related to including such as pointing devices, navigation equipment, smartphone and/or electronic devices.

WHAT IS CLAIMED IS:

1. An electronic device subject to movements and rotations in a spatial reference frame, comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

2. The electronic device of claim 1, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame.

3. The electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

4. The electronic device of claim 1, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

5. The electronic device of claim 1, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

6. The electronic device of claim 1, wherein the current quaternion and the predicted axial accelerations are converted from the measured angular velocities corresponding to time T so that the first comparison result and the updated quaternion correspond to time T.

7. The electronic device of claim 1, wherein the content is visual content.

8. The electronic device of claim 7, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

9. The electronic device of claim 8, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

10. The electronic device of claim 1, wherein:

the motion sensor module further comprises a magnetometer having magnetometer circuitry configured to generate measured magnetisms; and

in calculating the resulting deviation, the computing processor is further configured to:

convert the measured magnetisms corresponding to time T to a measured yaw angle and convert the angular velocities corresponding to time T to a predicted yaw angle;

compare the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtain the updated quaternion based on the second comparison result.

11. The electronic device of claim 10, wherein:

the measured yaw is based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from

the updated quaternion.

12. The electronic device of claim 10, wherein, in calculating the resulting deviation, the computing processor is further configured to:

obtain a first updated quaternion based on the current quaternion and the first comparison result; and

obtain a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

13. The electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtain the updated quaternion in response to determining that the compensation is needed.

14. The electronic device of claim 13, wherein, in calculating the resulting deviation, the computing processor is further configured to utilize the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range.

15. A method for determining movements and rotations in a spatial reference frame, comprising:

generating, with a motion sensor module having sensor circuitry, measured angular

velocities and measured axial accelerations;

calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion; and

providing content based on the resulting deviation in the spatial reference frame.

16. The method of claim 15, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the

rotations of an electronic device in a spatial reference frame.

17. The method of claim 15, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

18. The method of claim 15, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

19. The method of claim 15, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

20. The method of claim 15, wherein the current quaternion and the predicted axial accelerations are converted from the measured angular velocities corresponding to time T so that the first comparison result and the updated quaternion correspond to time T.

21. The method of claim 15, wherein the content is visual content.

22. The method of claim 21, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

23. The method of claim 22, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

24. The method of claim 15, wherein:

the method further comprises generating, with a magnetometer having magnetometer circuitry, measured magnetism; and

calculating the resulting deviation further comprises:

converting the measured magnetisms corresponding to time T to a measured yaw angle and converting the angular velocities corresponding to time T to a predicted yaw angle;

comparing the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtaining the updated quaternion based on the second comparison result.

25. The method of claim 24, wherein:

the measured yaw is calculated and obtained based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

26. The method of claim 24, wherein calculating the resulting deviation further comprises:

obtaining a first updated quaternion based on the current quaternion and the first comparison result; and

obtaining a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

27. The method of claim 15, wherein calculating the resulting deviation further comprises:

utilizing a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtaining the updated quaternion in response to determining that the compensation is needed.

28. The method of claim 27, wherein calculating the resulting deviation further comprises utilizing the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range.

ABSTRACT OF THE DISCLOSURE

A representative method involves: generating measured angular velocities and measured axial accelerations; calculating a resulting deviation associated with movements and rotations in a spatial reference frame by: providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1; converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations; comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result; obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion; and providing the resulting deviation based on the updated quaternion; and, providing content based on the resulting deviation in the spatial reference frame.

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
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.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

☒ Practitioners associated with Customer Number: 109673

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

☒ The address associated with Customer Number: 109673

OR

☐	Firm or Individual Name			
	Address			
	City		State	Zip
	Country			
	Telephone		Email	

Assignee Name and Address: CM HK Limited
RM 2401 24/F 101 KING'S RD
FORTRESS HILL, HONG KONG

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	June 15, 2017
Name	Shun-Nan Liou	Telephone	
Title	CEO of CM HK Limited		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. 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 3 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.

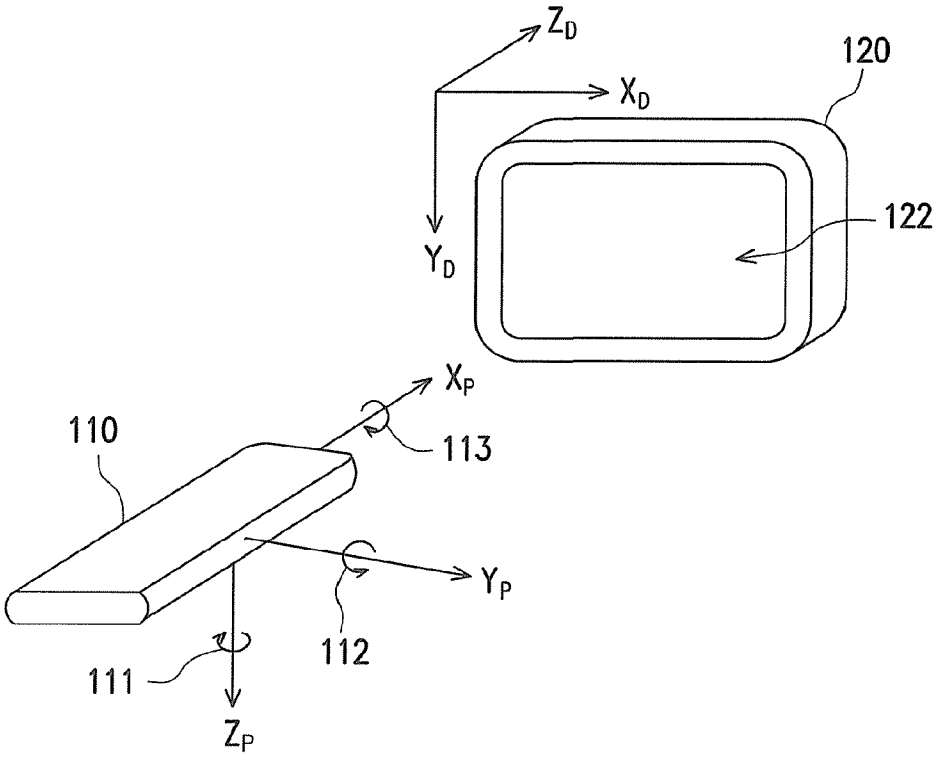


FIG. 1 (RELATED ART)

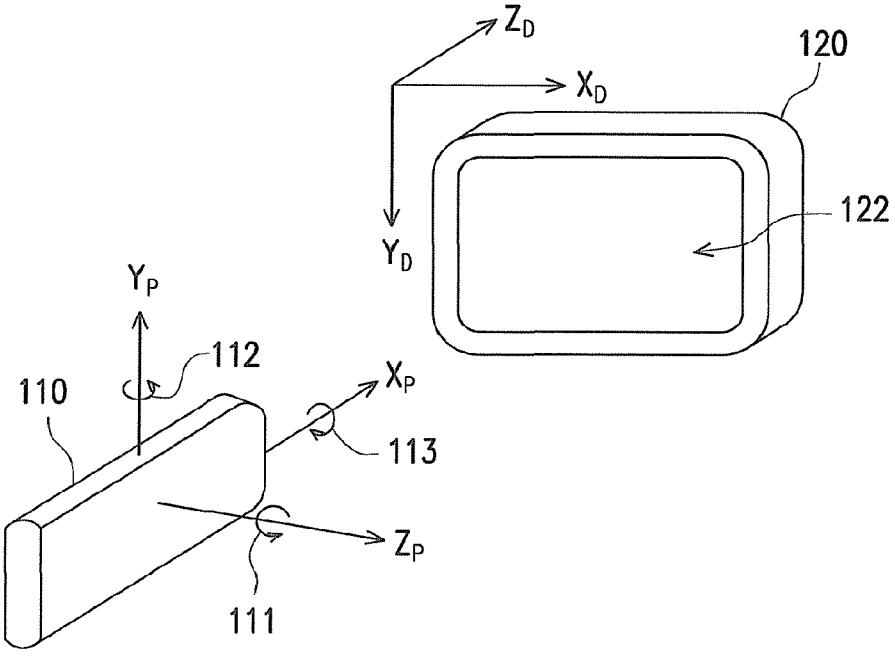


FIG. 2 (RELATED ART)

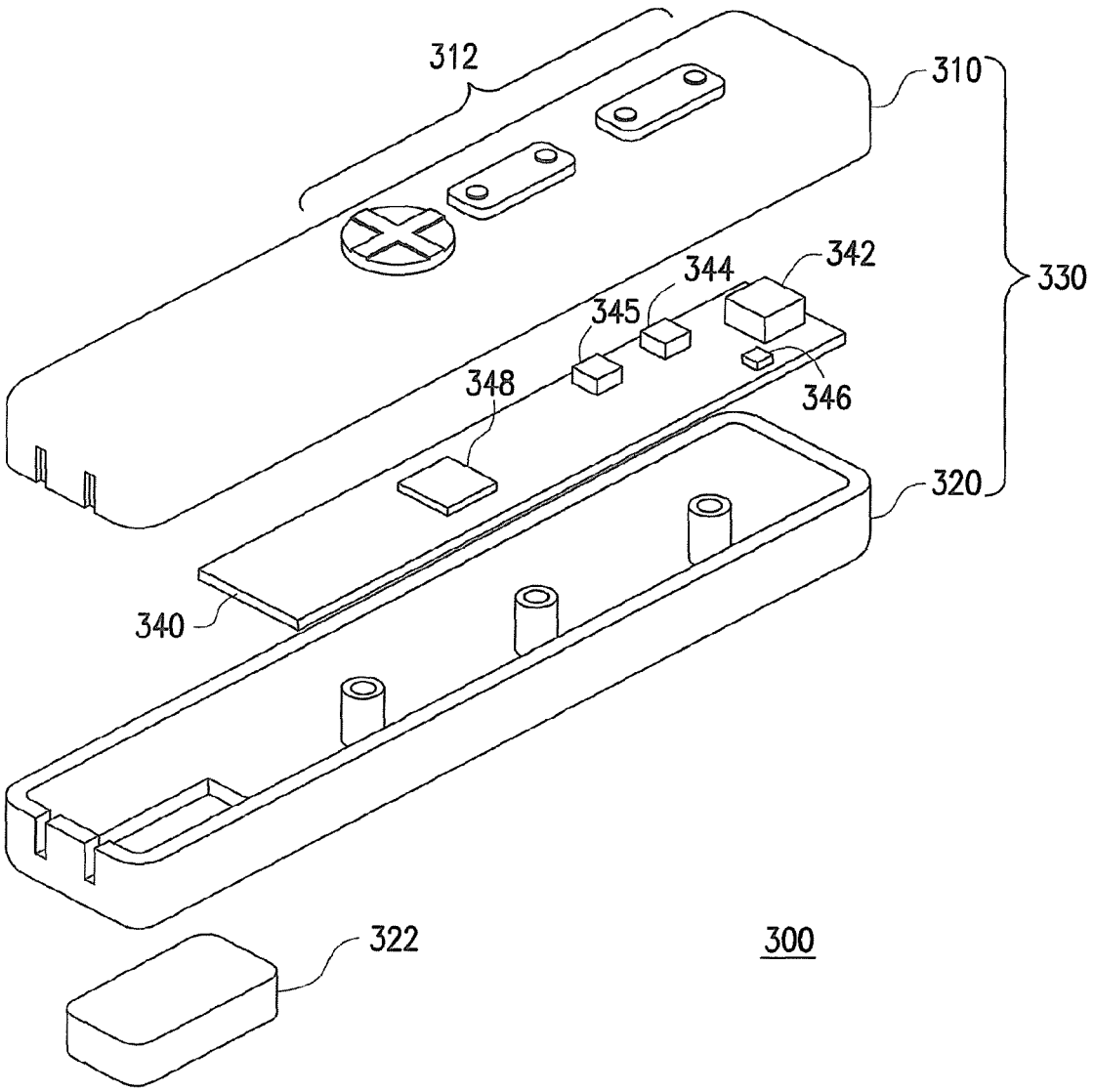


FIG. 3

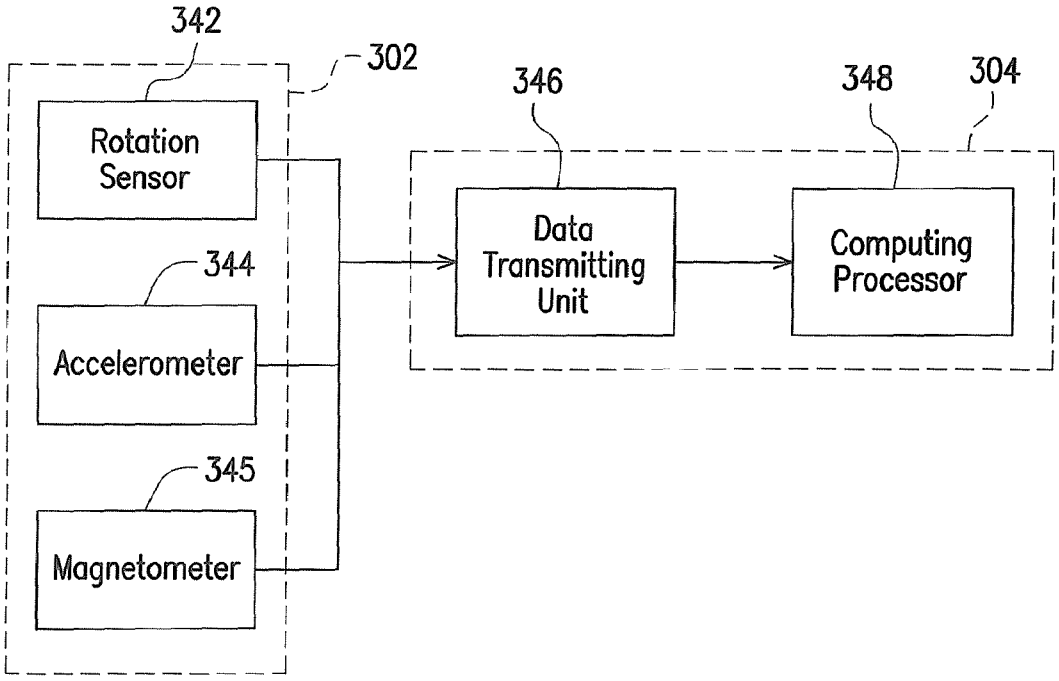

342
302
346
348
304
Rotation Sensor
344
Accelerometer
345
Magnetometer
Data Transmitting Unit
Computing Processor

FIG. 4

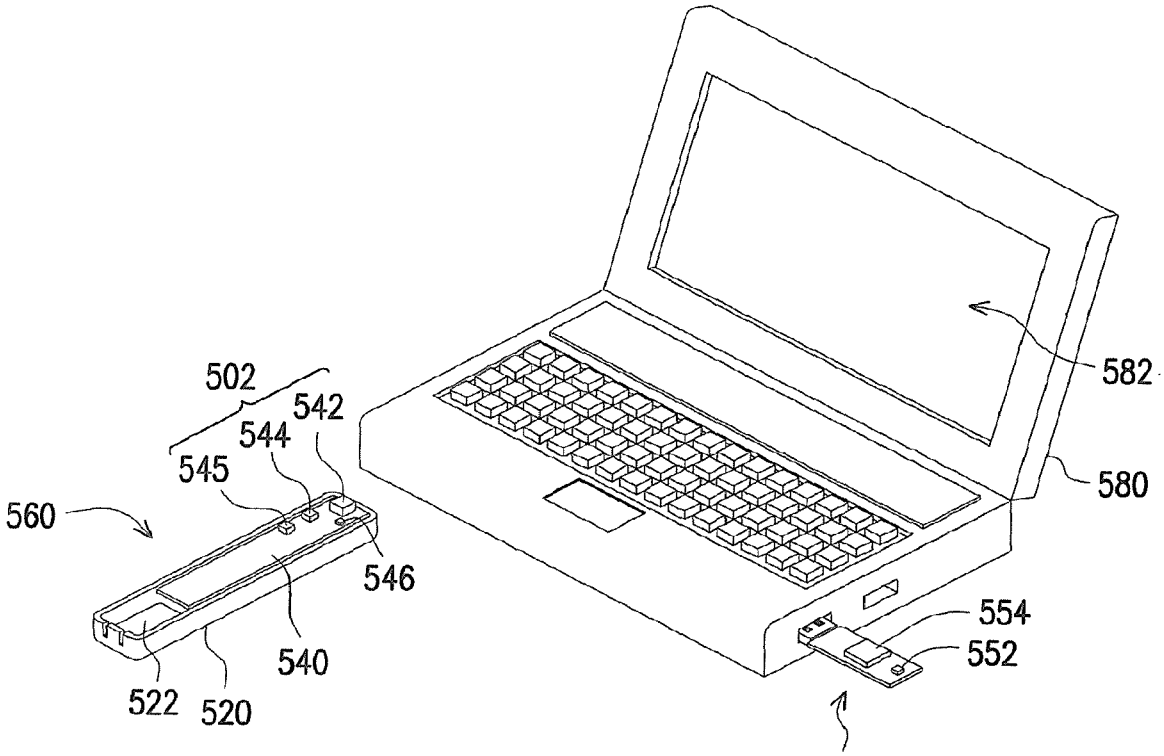

502
542
544
545
560
546
540
522
520
582
580
554
552
570

FIG. 5

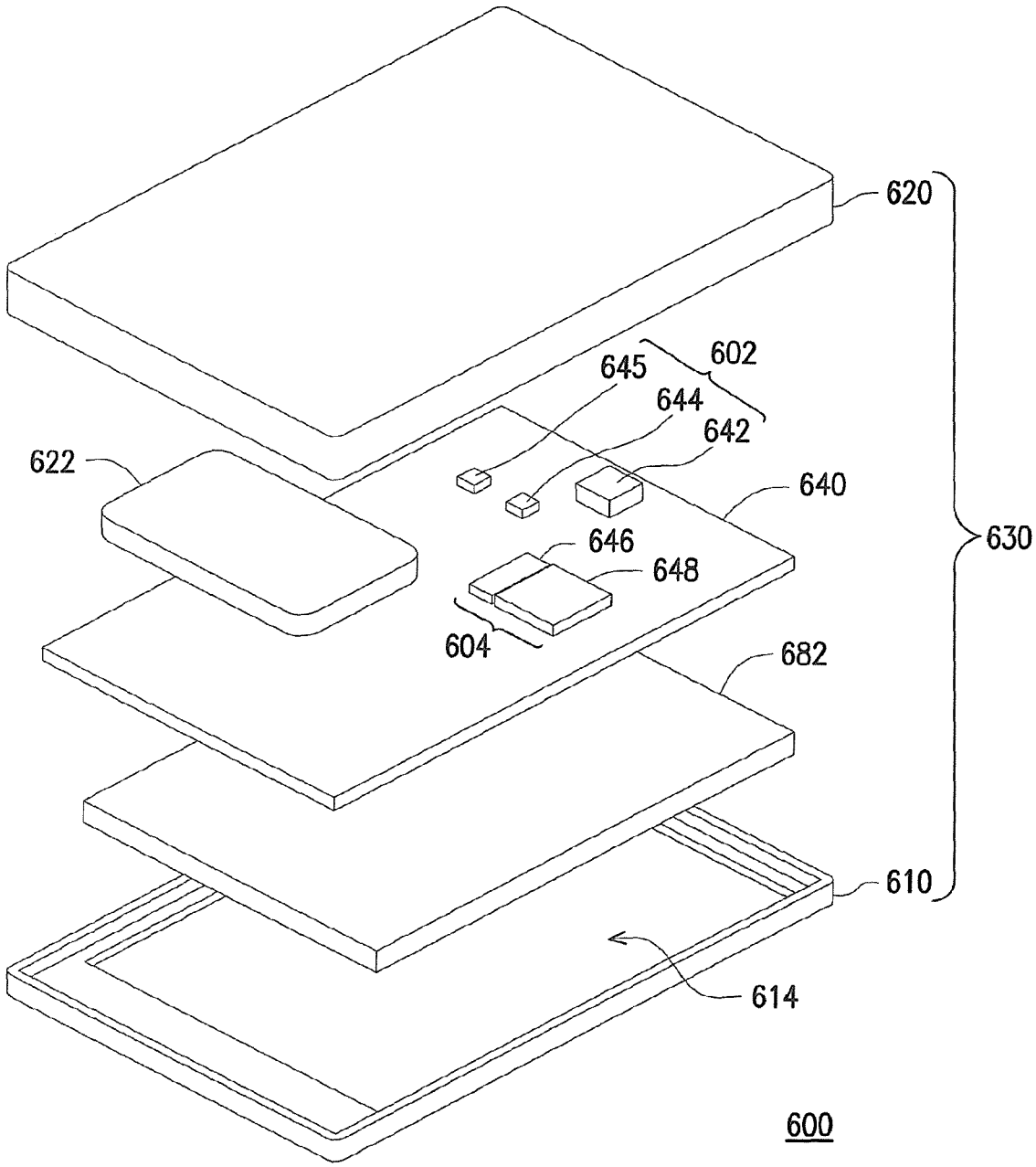


FIG. 6

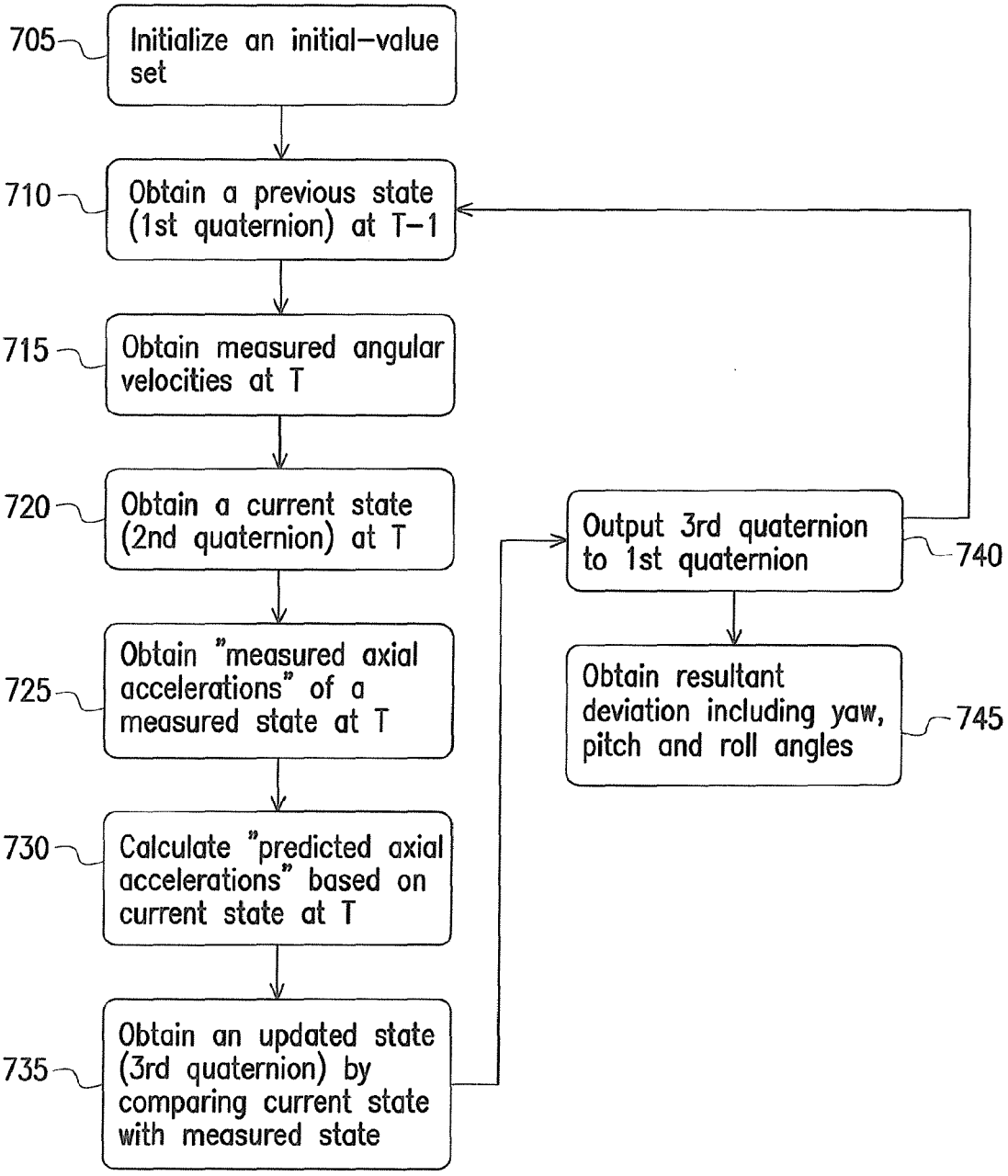

705
Initialize an initial-value set
710
Obtain a previous state (1st quaternion) at T-1
715
Obtain measured angular velocities at T
720
Obtain a current state (2nd quaternion) at T
725
Obtain "measured axial accelerations" of a measured state at T
730
Calculate "predicted axial accelerations" based on current state at T
735
Obtain an updated state (3rd quaternion) by comparing current state with measured state
740
Output 3rd quaternion to 1st quaternion
745
Obtain resultant deviation including yaw, pitch and roll angles

FIG. 7

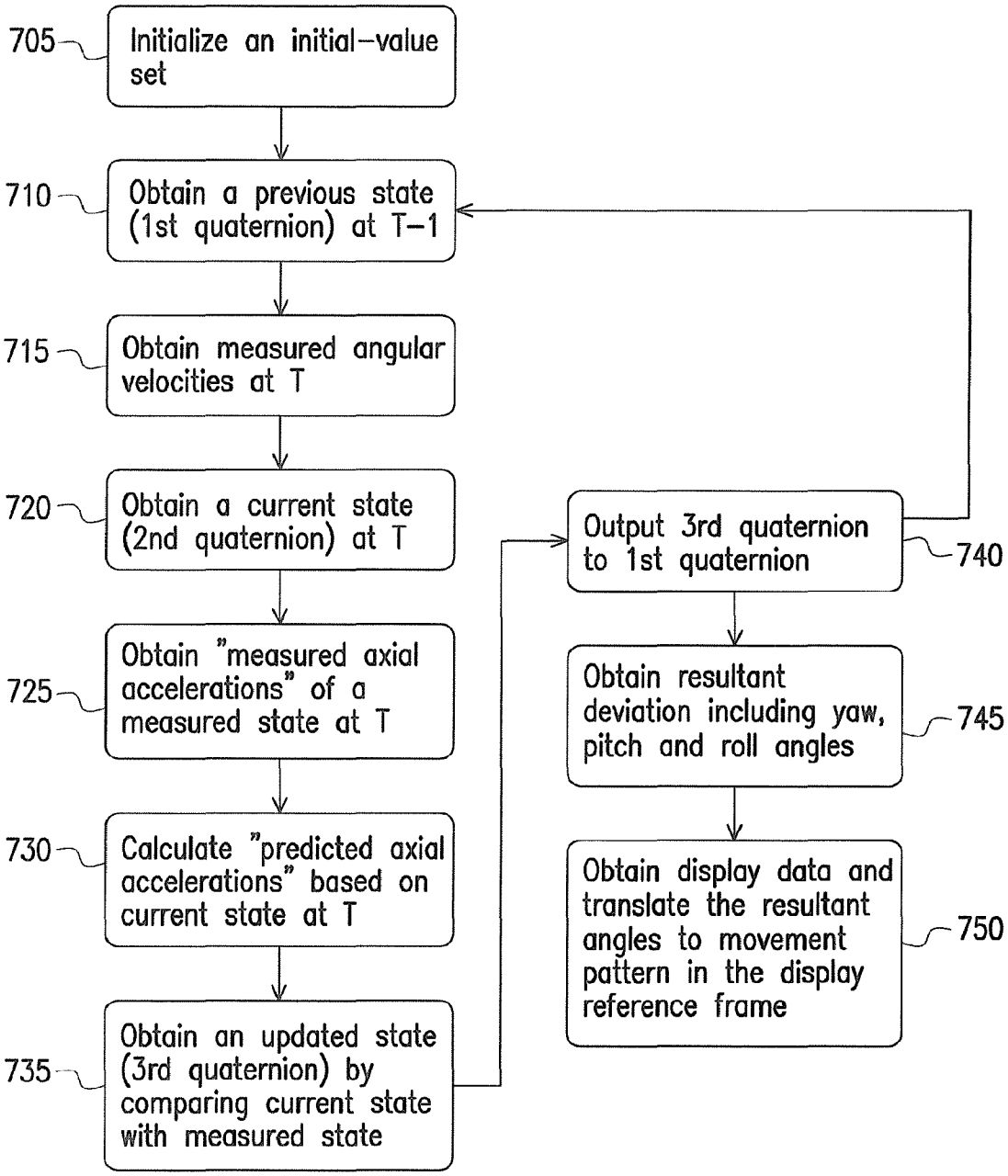

705
Initialize an initial-value set
710
Obtain a previous state (1st quaternion) at T-1
715
Obtain measured angular velocities at T
720
Obtain a current state (2nd quaternion) at T
725
Obtain "measured axial accelerations" of a measured state at T
730
Calculate "predicted axial accelerations" based on current state at T
735
Obtain an updated state (3rd quaternion) by comparing current state with measured state
740
Output 3rd quaternion to 1st quaternion
745
Obtain resultant deviation including yaw, pitch and roll angles
750
Obtain display data and translate the resultant angles to movement pattern in the display reference frame

FIG. 8

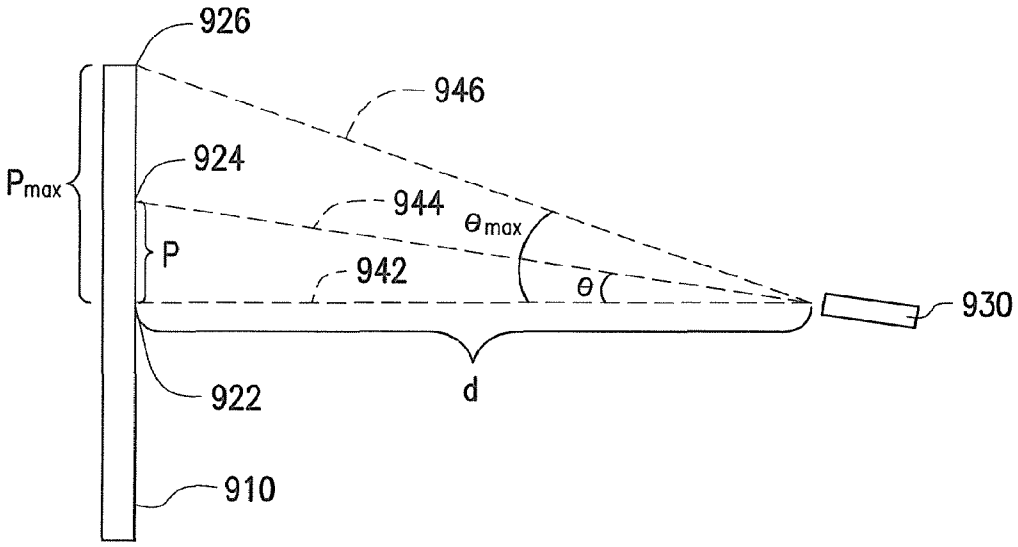


FIG. 9

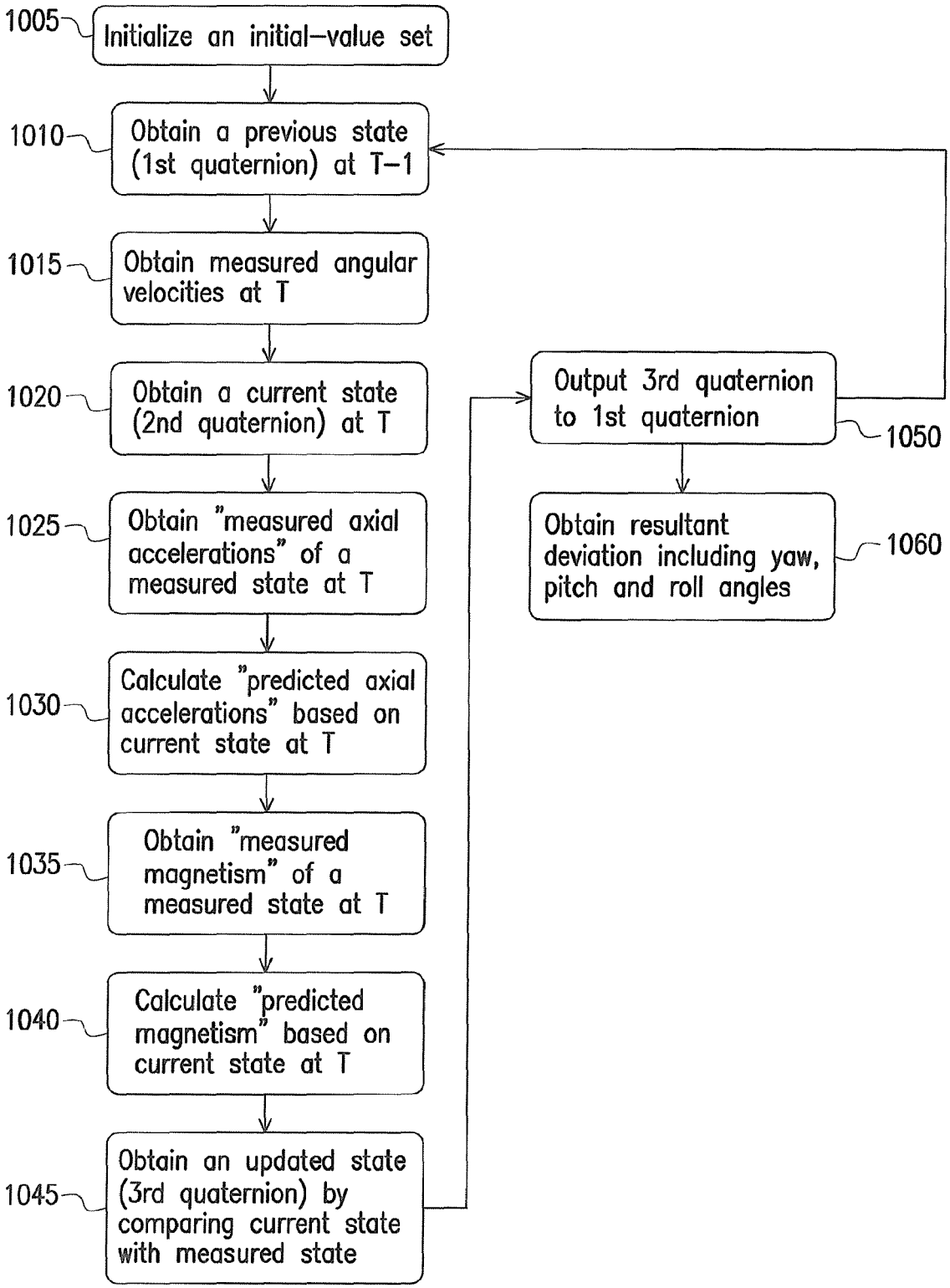

1005
Initialize an initial-value set
1010
Obtain a previous state (1st quaternion) at T-1
1015
Obtain measured angular velocities at T
1020
Obtain a current state (2nd quaternion) at T
1025
Obtain "measured axial accelerations" of a measured state at T
1030
Calculate "predicted axial accelerations" based on current state at T
1035
Obtain "measured magnetism" of a measured state at T
1040
Calculate "predicted magnetism" based on current state at T
1045
Obtain an updated state (3rd quaternion) by comparing current state with measured state
Output 3rd quaternion to 1st quaternion
1050
Obtain resultant deviation including yaw, pitch and roll angles
1060

FIG. 10

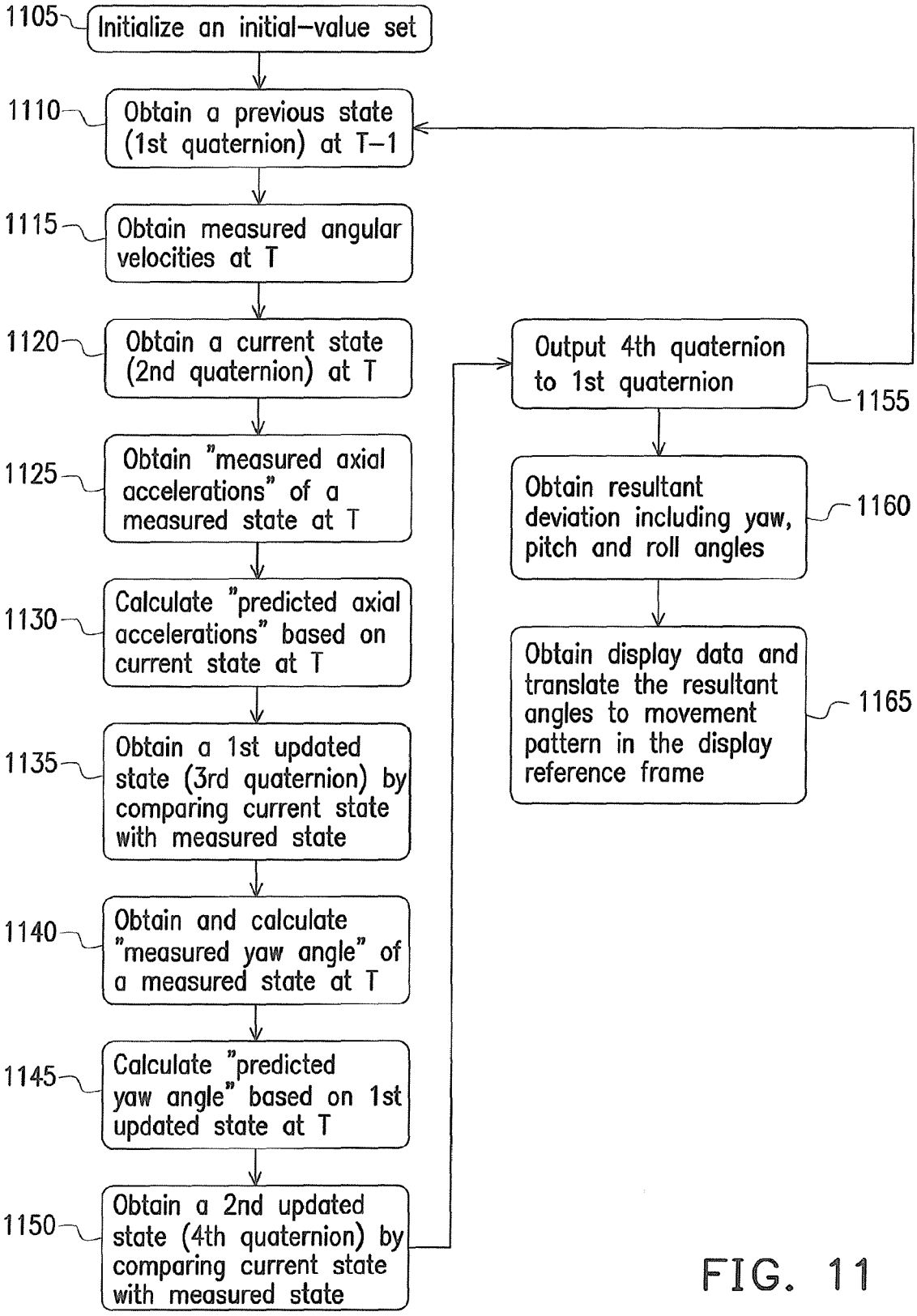

1105
Initialize an initial-value set
1110
Obtain a previous state (1st quaternion) at T-1
1115
Obtain measured angular velocities at T
1120
Obtain a current state (2nd quaternion) at T
1125
Obtain "measured axial accelerations" of a measured state at T
1130
Calculate "predicted axial accelerations" based on current state at T
1135
Obtain a 1st updated state (3rd quaternion) by comparing current state with measured state
1140
Obtain and calculate "measured yaw angle" of a measured state at T
1145
Calculate "predicted yaw angle" based on 1st updated state at T
1150
Obtain a 2nd updated state (4th quaternion) by comparing current state with measured state
Output 4th quaternion to 1st quaternion
1155
Obtain resultant deviation including yaw, pitch and roll angles
1160
Obtain display data and translate the resultant angles to movement pattern in the display reference frame
1165

FIG. 11

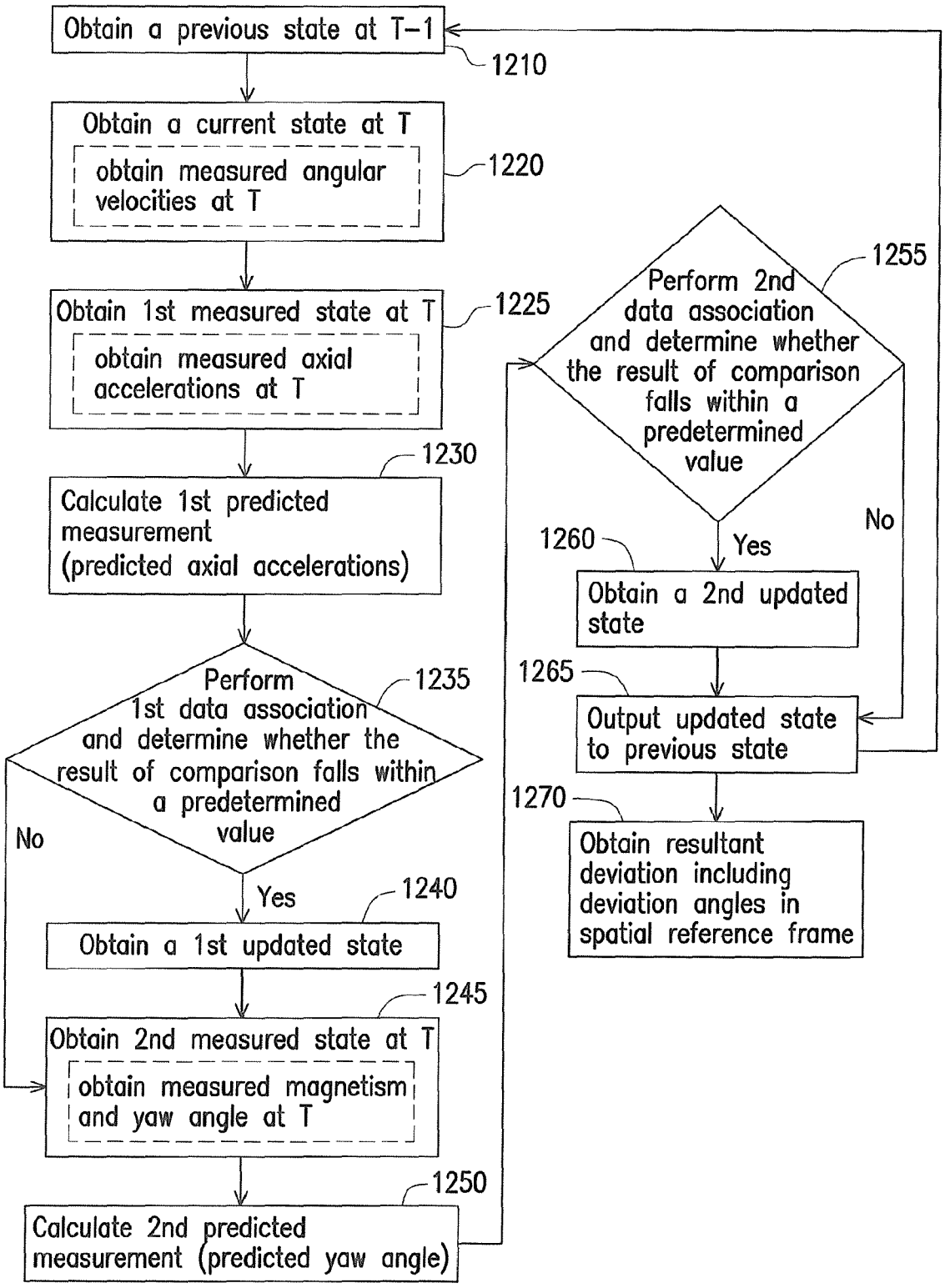

Obtain a previous state at T-1
1210
Obtain a current state at T
obtain measured angular velocities at T
1220
Obtain 1st measured state at T
obtain measured axial accelerations at T
1225
Calculate 1st predicted measurement (predicted axial accelerations)
1230
Perform 1st data association and determine whether the result of comparison falls within a predetermined value
1235
No
Yes
Obtain a 1st updated state
1240
Obtain 2nd measured state at T
obtain measured magnetism and yaw angle at T
1245
Calculate 2nd predicted measurement (predicted yaw angle)
1250
Perform 2nd data association and determine whether the result of comparison falls within a predetermined value
1255
No
Yes
Obtain a 2nd updated state
1260
Output updated state to previous state
1265
Obtain resultant deviation including deviation angles in spatial reference frame
1270

FIG. 12

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
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.

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [x] The attached application, or
- [ ] United States application or PCT international application number _____

filed on _____.

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: Shun-Nan Liou Date (Optional): _____

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.**

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.

Doc code: Oath
Document Description: Oath or declaration filed

PTO/AIA/02 (07-13)
Approved for use through 04/30/2017. 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.

SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

This statement is directed to:

☒ The attached application,

OR

☐ United States application or PCT international application number _____ filed on _____

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

Zhou Ye

Residence (except for a deceased or legally incapacitated inventor):

City	State	Country
Taipei		TW

Mailing Address (except for a deceased or legally incapacitated inventor):

5F-2, No.12, Wenhu St., Neihu Dist.

City	State	Zip	Country
Taipei		11445	TW

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

- ☐ Legal Representative (for deceased or legally incapacitated inventor only),
- ☐ Assignee,
- ☒ Person to whom the inventor is under an obligation to assign,
- ☐ Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or
- ☐ Joint 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.**

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

PTO/SB/AIA02 (07-13)
Approved for use through 01/31/2014. 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.

SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- ☐ Inventor is deceased.
- ☐ Inventor is under legal incapacity.
- ☒ Inventor cannot be found or reached after diligent effort, or
- ☐ Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- ☒ An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

- ☐ An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

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.

PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name: Shun-Nan Liou

Date (Optional):

Signature:

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: CM HK LIMITED

Title of Person Executing This Substitute Statement: CEO

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City | State | Country Hong Kong

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

City | State | Zip | Country

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

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.

Doc code: Oath
Document Description: Oath or declaration filed

PTO/AIA/02 (07-13)
Approved for use through 04/30/2017. 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.

SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

This statement is directed to:

☒ The attached application,

OR

☐ United States application or PCT international application number _____ filed on _____

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

Chin-Lung Li

Residence (except for a deceased or legally incapacitated inventor):

City	State	Country
Taipei		TW

Mailing Address (except for a deceased or legally incapacitated inventor):

5F-2, No.12, Wenhu St., Neihu Dist.

City	State	Zip	Country
Taipei		11445	TW

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

- ☐ Legal Representative (for deceased or legally incapacitated inventor only),
- ☐ Assignee,
- ☒ Person to whom the inventor is under an obligation to assign,
- ☐ Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or
- ☐ Joint 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.**

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

PTO/SB/AIA02 (07-13)
Approved for use through 01/31/2014. 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.

SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- ☐ inventor is deceased,
- ☐ inventor is under legal incapacity,
- ☒ inventor cannot be found or reached after diligent effort, or
- ☐ inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- ☒ An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

- ☐ An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

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.

PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name: Shun-Nan Liou | Date (Optional):

Signature:

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: CM HK LIMITED

Title of Person Executing This Substitute Statement: CEO

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City | State | Country Hong Kong

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

City | State | Zip | Country

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

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

In Re Application of:

Confirmation No.: Unassigned

Shun-Nan LIOU, et al.

Examiner: Unassigned

Serial No. Unassigned

Docket No. 250303-1022

Filing Date: November 20, 2020

Group Art Unit: Unassigned

For: Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof

INFORMATION DISCLOSURE STATEMENT

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

Commissioner:

This information disclosure statement is filed in accordance with 37 C.F.R. §§ 1.56, 1.97, and 1.98. Listed on the accompanying form SB_08(a) are documents which may or may not be considered material to the examination of this application. These documents were made of record in a prior application filed June 2, 2017, and having serial no. 15/611,970, to which priority is claimed relative to the present application pursuant to 35 U.S.C. §120. Copies of these documents are not being provided pursuant to 37 C.F.R. § 1.98(d)(1) and (2), which provides:

> (d) A copy of any patent, publication, pending U.S. application or other information, as specified in paragraph (a) of this section, listed in an information disclosure statement is required to be provided, even if the patent, publication, pending U.S. application or other information was previously submitted to, or cited by, the Office in an earlier application, unless:
>
> (1) The application is properly identified in the information disclosure statement and is relied on for an earlier effective filing date under 35 U.S.C. §120; and

(2) The information disclosure statement submitted in the earlier application complies with a paragraphs (a) through (c) of this section.

Please note that U.S. Patent No. 6,993,451 is the English language counterpart to Chinese reference no. CN 1573672. U.S. Patent No. 7,389,590 is the English language counterpart to Chinese reference no. CN 1971310. U.S. Publication No. 2007/273645 is the English language counterpart to Chinese reference no. CN 101078957. U.S. Patent No. 8,531,399 is the English language counterpart to Chinese reference no. CN 101606120.

The abstract provided for CN 100440313 is from corresponding application no. CN 1973316.

The following rights are reserved by the Applicant(s): the right to establish the patentability of the claimed invention over any of the listed documents should they be applied as reference, the right to prove that some of these documents may not be prior art, and/or the right to prove that some of these documents may not be enabling for the teachings they purport to offer.

This statement should not be construed as a representation that an exhaustive search has been made, or that information more material to the examination of the present application does not exist. The Examiner is specifically requested not to rely solely on the materials submitted herewith. The Examiner is requested to conduct an independent and thorough review of the documents, and to form independent opinions as to their significance.

It is respectfully requested that the Examiner initial and return a copy of the enclosed PTO-1449 to indicate the documents have been considered.

Respectfully submitted,

McClure, Qualey & Rodack, LLP

/M.PaulQualey,Jr./

By: _____

M. Paul Qualey, Jr., Reg. No. 43,024

Customer No. 109673

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

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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 contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

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	6993451	B2	2006-01-31	Chang, et al.	
	2	7389590	B2	2008-06-24	Lee, et al.	
	3	8531399	B2	2013-09-10	Kabasawa, et al.	
	4	5181181	A	1993-01-19	Glynn	
	5	5453758	A	1995-09-26	Sato	
	6	7089148	B1	2006-08-08	Bachmann, et al.	
	7	7414611	B2	2008-08-19	Liberty	
	8	6957156	B2	2005-10-18	Jo, et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	9	5138154	A	1992-08-11	Hotelling	
	10	5440326	A	1995-08-08	Quinn	
	11	5898421	A	1999-04-27	Quinn	
	12	7158118	B2	2007-01-02	Liberty	
	13	7236156	B2	2007-06-26	Liberty, et al.	
	14	7239301	B2	2007-07-03	Liberty, et al.	
	15	7262760	B2	2007-08-28	Liberty	
	16	7489298	B2	2009-02-10	Liberty, et al.	
	17	7535456	B2	2009-05-19	Liberty, et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear

EFS Web 2.1.18

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	1	20070273645	A1	2007-11-29	Bang, et al.		
	2	20040095317	A1	2004-05-20	Zhang, et al.		
	3	20070091068	A1	2007-04-26	Liberty		
	4	20090115724	A1	2009-05-07	Yamamoto		
	5	20110199298	A1	2011-08-18	Bassompiere, et al.		
	6	20100161084	A1	2010-06-24	Zhao, et al.		
	7	20090182503	A1	2009-07-16	Changey, et al.		
	8	20090262074	A1	2009-10-22	Nasiri, et al.		

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	102778965	CN	A	2012-11-14	BRITISH VIRGIN ISLANDS CYWEE CO LTD	Abstract	X

EFS Web 2.1.18

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	2	102778965	CN	A	2012-11-14	BRITISH VIRGIN ISLANDS CYWEE CO LTD		☐
	3	1573672	CN	A	2005-02-02	SAMSUNG ELECTRONICS CO LTD	Abstract	☒
	4	1573672	CN	A	2005-02-02	SAMSUNG ELECTRONICS CO LTD		☐
	5	1971310	CN	A	2007-05-30	SAMSUNG ELECTRONICS CO LTD	Abstract	☒
	6	1971310	CN	A	2007-05-30	SAMSUNG ELECTRONICS CO LTD		☐
	7	100440313	CN	C	2008-12-03	HILLCREST LAB INC	Abstract	☐
	8	100440313	CN	C	2008-12-03	HILLCREST LAB INC		☐
	9	101078957	CN	A	2007-11-28	SAMSUNG ELECTRONICS CO LTD	Abstract	☒
	10	101078957	CN	A	2007-11-28	SAMSUNG ELECTRONICS CO LTD		☐
	11	101173858	CN	A	2008-05-07	BEIJING CONTROL ENGINEERING IN	Abstract	☒
	12	101173858	CN	A	2008-05-07	BEIJING CONTROL ENGINEERING IN		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	13	101256456	CN	A	2008-09-03	HILLCREST COMM INC	Abstract	☒
	14	101256456	CN	A	2008-09-03	HILLCREST COMM INC		☐
	15	101377722	CN	A	2009-03-04	IND TECH RES INST	Abstract	☒
	16	101377722	CN	A	2009-03-04	IND TECH RES INST		☐
	17	101427570	CN	A	2009-05-06	HILLCREST LAB INC	Abstract	☒
	18	101427570	CN	A	2009-05-06	HILLCREST LAB INC		☐
	19	101472095	CN	A	2009-07-01	PIXART IMAGING INC	Abstract	☒
	20	101472095	CN	A	2009-07-01	PIXART IMAGING INC		☐
	21	101606120	CN	A	2009-12-16	SONY CORP	Abstract	☒
	22	101606120	CN	A	2009-12-16	SONY CORP		☐
	23	101726295	CN	A	2010-06-09	CHINESE ACAD INST AUTOMATION	Abstract	☒

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	24	101726295	CN	A	2010-06-09	CHINESE ACAD INST AUTOMATION		☐
	25	101788860	CN	A	2010-07-28	YUANZHAN TECHNOLOGIES CO LTD	Abstract	☒
	26	101788860	CN	A	2010-07-28			☐
	27	101872259	CN	A	2010-10-27	SECOND ARTILLERY ENGINEERING UNIVERSITY OF THE CHI	Abstract	☒
	28	101872259	CN	A	2010-10-27	SECOND ARTILLERY ENGINEERING UNIVERSITY OF THE CHI		☐
	29	101915580	CN	A	2010-12-15	CHINESE ACAD INST AUTOMATION	Abstract	☒
	30	101915580	CN	A	2010-12-15	CHINESE ACAD INST AUTOMATION		☐
	31	102778965	CN	B	2017-04-12	BRITISH VIRGIN ISLANDS CYWEE CO LTD		☐
	32	201514612	CN	U	2010-06-23	JIANKANG WU	Abstract	☒
	33	201514612	CN	U	2010-06-23	JIANKANG WU		☐
	34	1 731 996	EP	A2	2006-12-13	ZHANG GUANGLIE; SHI GUANGYI; LUO YILUN; et al.		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	35	2007-183138	JP	A	2007-07-19	NONAMI KENZO; SHIN SHIN; SUZUKI SATOSHI; NAKAZAWA	Abstract	☒
	36	2007-183138	JP	A	2007-07-19	NONAMI KENZO; SHIN SHIN; SUZUKI SATOSHI; NAKAZAWA		☐
	37	10-2009-0106767	KR	A	2009-10-12	LG ELECTRONICS INC	Abstract	☒
	38	10-2009-0106767	KR	A	2009-10-12	LG ELECTRONICS INC		☐
	39	10-2010-0091854	KR	A	2010-08-19	LG ELECTRONICS INC	Abstract	☒
	40	10-2010-0091854	KR	A	2010-08-19	LG ELECTRONICS INC		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

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	Chinese language office action dated 2019-05-15, issued in application no. CN 201210084834.6.	
	2	Chinese language office action dated 2019-05-16, issued in application no. CN 201210084834.6.	
	3	Chinese language office action dated 2019-05-17, issued in application no. CN 201210084834.6.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	4	Chinese language document; 2009; pps. 486-659	
	5	Chinese language document; 2015; pps. 242-659	
	6	Chinese language office action dated 2020-01-03, issued in application no. 201710093370.8.	
	7	Chinese language office action dated 2019-04-25, issued in application no. 201710093370.8.	
	8	Azuma, Ronald et al. Improving Static and Dynamic Registration in an Optical See-Through HMO. Proceedings of SIGGRAPH '94 (Orlando, Fla., 24 29 Jul., 1994), Computer Graphics, Annual Conference Series, 1994, 197 204.	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

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	/M.PaulQualey,Jr./	Date (YYYY-MM-DD)	2020-11-20
Name/Print	M. Paul Qualey Jr.	Registration Number	43,024

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.**

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 the Freedom of Information Act requires disclosure of these record s.

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 inspections 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.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
16/953,771	11/20/2020	2621	1230	250303-1022	28	2

CONFIRMATION NO. 1038

109673
McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 550
Atlanta, GA 30339

FILING RECEIPT

OC000000122036272

Date Mailed: 12/16/2020

Receipt is acknowledged of this non-provisional utility 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 FIRST INVENTOR, 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 corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction 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 provided that the request is grantable.

Inventor(s)

Shun-Nan LIOU, Taipei, TAIWAN;
Zhou YE, Taipei, TAIWAN;
Chin-Lung LI, Taipei, TAIWAN;

Applicant(s)

CM HK LIMITED, Fortress Hill, HONG KONG;

Power of Attorney: The patent practitioners associated with Customer Number 109673

Domestic Priority data as claimed by applicant

This application is a CON of 15/611,970 06/02/2017 PAT 10852846
which is a CON of 13/072,794 03/28/2011 PAT 9760186
which is a CIP of 12/943,934 11/11/2010 PAT 8441438
which claims benefit of 61/292,558 01/06/2010

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: 12/15/2020
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/953,771**
Projected Publication Date: 03/25/2021
Non-Publication Request: No
Early Publication Request: No
**** SMALL ENTITY ****
Title

ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

Preliminary Class

345

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).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

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 U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022

CONFIRMATION NO. 1038

109673
McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 550
Atlanta, GA 30339

PUBLICATION NOTICE

OC000000124372267

Title:ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

Publication No.US-2021-0089142-A1
Publication Date:03/25/2021

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.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

109673 7590 12/08/2021

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 550
Atlanta, GA 30339

EXAMINER
EARLES, BRYAN E

ART UNIT	PAPER NUMBER
2625	

NOTIFICATION DATE	DELIVERY MODE
12/08/2021	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):

callie.reynolds@mqrlaw.com
dan.mcclure@mqrlaw.com
uspatents@mqrlaw.com

PTOL-90A (Rev. 04/07)

Office Action Summary	**Application No.** 16/953,771	**Applicant(s)** LIOU et al.	
	Examiner BRYAN EARLES	**Art Unit** 2625	**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 20 November 2020.

☐ 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) 1-28 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) 1-28 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 20 November 2020 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 _____.

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

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

Claim Rejections - 35 USC § 103

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.

Claims 1-28 are rejected under 35 U.S.C. 103 as being unpatentable over Yamashita et al. (US 8,267,785, hereinafter "Yamashita") in view of Bachmann et al. (US 7,089,148, hereinafter "Bachmann").

With respect to **claim 1**, Yamashita teaches an electronic device subject to movements and rotations in a spatial reference frame (Yamashita: Fig. 1-3), comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations (Yamashita: Fig. 7, gyrosensor unit 7 includes gyrosensors 55 and 56 for producing tri-axial angular velocity data).

Yamashita fails to expressly disclose:

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

However, Bachmann discloses:

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame (Bachmann: Fig. 3, the angular rates (p, q, r) at box 33 correspond to measured movements and rotations in a sensor reference frame) by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1 (Bachmann: Fig. 3, the previous quaternion corresponds to the prior orientation output quaternion at 39);

converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations (Bachmann: Fig. 3, the angular rates at box 33 are converted at box 37 to a rate quaternion);

comparing (Paragraph [0004], of Applicant's Specification, "The term of "comparison" of the present invention may generally refer to the calculating and obtaining of the actual deviation angles of the 3D pointing device …") the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result (Bachmann: Fig. 3, the comparison occurs at the junction between boxes 34 and 35, such that the filter chooses a correction factor, that when added to q.dot., will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values);

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion (Bachmann: Fig. 3, the updated quaternion is a new value of the orientation output quaternion at 39); and

providing the resulting deviation based on the updated quaternion (Bachmann: Fig. 3, the updated quaternion reflects the correction factor using predicted measurements based on the previous orientation output quaternion);

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame (Bachmann: Fig. 4, processing unit translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

Therefore, it would be obvious to one of ordinary skill in the art at the time the invention was made to modify the method, as taught by Yamashita, to incorporate additional types of detectors into the motion sensing module, as taught by Bachmann, in order overcome the shortcomings of individual detector types by capitalizing on the advantages of each (Bachmann: Col. 4, lines 15-30, Col. 13, lines 1-10).

With respect to **claim 2**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer (Yamashita: Fig. 7, gyrosensor unit 7 and acceleration sensor 37);

the rotation sensor has sensor circuitry configured to generate the measured angular velocities (Yamashita: Fig. 7, gyrosensor unit 7 includes gyrosensors 55 and 56 for producing tri-axial angular velocity data);

the accelerometer has circuitry configured to generate the measured axial accelerations (Yamashita: Fig. 7; Col. 12, line 47 – Col. 13, line 10, output from the acceleration sensor 37 represented as a three-dimensional acceleration vector (ax,ay,az));

and both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame

(Yamashita: Fig. 7; Col. 12, line 47 – Col. 13, line 10, output from the acceleration sensor 37 represented as a three-dimensional vector (ax,ay,az) in a XYZ coordinate system).

With respect to **claim 3**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T (Bachmann: Fig. 3, the angular rates at box 33 are converted at box 37 to a rate quaternion).

With respect to **claim 4** the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T (Bachmann: Fig. 3, an estimated orientation quaternion 39 is correlated with the measurement vector 34 and the angular rate information 37; Col. 16, line 40 – Col. 17, line 5, each iteration computes an updated estimated quaternion representative of a new estimate of sensor orientation).

With respect to **claim 5**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T (Bachmann: Fig. 3, the comparison occurs at the junction between boxes 34 and 35,

such that the filter chooses a correction factor, that when added to q.dot., will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values).

With respect to **claim 6**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the current quaternion and the predicted axial accelerations are converted from the measured angular velocities corresponding to time T so that the first comparison result and the updated quaternion correspond to time T (Bachmann: Fig. 3, an estimated orientation quaternion 39 is correlated with the measurement vector 34 and the angular rate information 37; Col. 16, line 40 – Col. 17, line 5, each iteration computes an updated estimated quaternion representative of a new estimate of sensor orientation).

With respect to **claim 7**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the content is visual content (Bachmann: Fig. 4, Col. 13, lines 20-30).

With respect to **claim 8**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 7, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame (Bachmann: Fig. 4, processing unit translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

With respect to **claim 9**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 8, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern (Bachmann: Fig. 4, processing unit translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

With respect to **claim 10**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein:

the motion sensor module further comprises a magnetometer having magnetometer circuitry configured to generate measured magnetisms (Bachmann: Fig. 3, magnetometers 38 generate measured magnetisms b1, b2, b3); and

in calculating the resulting deviation, the computing processor is further configured to:

convert the measured magnetisms corresponding to time T to a measured yaw angle (Bachmann: Fig. 3, box 32 outputs measured magnetisms b1, b2, b3 corresponding to yaw pitch and roll angles) and convert the angular velocities corresponding to time T to a predicted yaw angle (Bachmann: Fig. 3, box 33 outputs signal (p, q, r) comprising angular velocities Ωx, Ωy, Ωz. used to calculate each output $\hat{q}$ and are therefore a part of each orientation output quaternion q);

compare the predicted yaw angle with the measured yaw angle to obtain a second comparison result (Bachmann: Fig. 3, measured magnetisms are compared with respective predicted magnetisms in the computed measurement vector 35a to obtain a six-valued error vector 36 that corresponds to measure of how actual

accelerometer and magnetometer measurements differ from the what the filter predicts those measurements should be, based on the angular rate sensor output (Bachmann: Fig. 3, the filter selects a correction factor output at box 41 that when added to the output at box 37 will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values); and

obtain the updated quaternion based on the second comparison result (Bachmann: Fig. 3, the filter selects a correction factor output at box 41 that when added to the output at box 37 will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values).

With respect to **claim 11**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 10, wherein:

the measured yaw is based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion (Bachmann: Fig. 3, includes intermediate sensor orientations represented in the form of quaternions (e.g., old and new q.sub.circumflex); Col. 7, lines 4-31; transforming estimated body rates to updated Euler Rates or Quaternion Rates)..

With respect to **claim 12**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 10, wherein, in calculating the resulting deviation, the computing processor is further configured to:

obtain a first updated quaternion based on the current quaternion and the first comparison result (Bachmann: Fig. 3, an estimated orientation quaternion 39 is correlated with the measurement vector 34 and the angular rate information 37; Col. 16, line 40 – Col. 17, line 5, each iteration computes an updated estimated quaternion representative of a new estimate of sensor orientation); and

obtain a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion (Bachmann: Col. 9, lines 22-32; Fig. 3, a second updated state is interpreted as a subsequent iteration using the previously updated state; Equation 16).

With respect to **claim 13**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtain the updated quaternion in response to determining that the compensation is needed (Bachmann: Fig. 3; performing compensation if the error vector yields a non-zero result, then no deviation exist in the subtracting operation between the actual

measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values then no compensation is performed).

With respect to **claim 14**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 13, wherein, in calculating the resulting deviation, the computing processor is further configured to utilize the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range (Bachmann: Fig. 3; performing the compensation only if the error vector yields a non-zero result, otherwise if no deviation exist in the subtracting operation between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values, then no compensation is performed).

Method claims (15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 & 28) are drawn to the method of using the corresponding apparatus claimed in claims (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 & 14). Therefore method claims (15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 & 28) correspond to apparatus claims (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 & 14) and are rejected for the same reasons of obviousness as used above.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to BRYAN EARLES whose telephone number is (571)272-

4628. The examiner can normally be reached on Monday - Thursday at 7:30am - 5:00pm.

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, William Boddie can be reached on 571-272-0666. 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.

/BRYAN EARLES/
Primary Examiner, Art Unit 2625

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

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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 contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2020-11-20
First Named Inventor	Shun-Nan LIOU, et al.
Art Unit	
Examiner Name	
Attorney Docket Number	250303-1022

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	6993451	B2	2006-01-31	Chang, et al.	
	2	7389590	B2	2008-06-24	Lee, et al.	
	3	8531399	B2	2013-09-10	Kabasawa, et al.	
	4	5181181	A	1993-01-19	Glynn	
	5	5453758	A	1995-09-26	Sato	
	6	7089148	B1	2006-08-08	Bachmann, et al.	
	7	7414611	B2	2008-08-19	Liberty	
	8	6957156	B2	2005-10-18	Jo, et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	9	5138154	A	1992-08-11	Hotelling	
	10	5440326	A	1995-08-08	Quinn	
	11	5898421	A	1999-04-27	Quinn	
	12	7158118	B2	2007-01-02	Liberty	
	13	7236156	B2	2007-06-26	Liberty, et al.	
	14	7239301	B2	2007-07-03	Liberty, et al.	
	15	7262760	B2	2007-08-28	Liberty	
	16	7489298	B2	2009-02-10	Liberty, et al.	
	17	7535456	B2	2009-05-19	Liberty, et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	1	20070273645	A1	2007-11-29	Bang, et al.	
	2	20040095317	A1	2004-05-20	Zhang, et al.	
	3	20070091068	A1	2007-04-26	Liberty	
	4	20090115724	A1	2009-05-07	Yamamoto	
	5	20110199298	A1	2011-08-18	Bassompiere, et al.	
	6	20100161084	A1	2010-06-24	Zhao, et al.	
	7	20090182503	A1	2009-07-16	Changey, et al.	
	8	20090262074	A1	2009-10-22	Nasiri, et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	102778965	CN	A	2012-11-14	BRITISH VIRGIN ISLANDS CYWEE CO LTD	Abstract	X

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	2	102778965	CN	A	2012-11-14	BRITISH VIRGIN ISLANDS CYWEE CO LTD		☐
	3	1573672	CN	A	2005-02-02	SAMSUNG ELECTRONICS CO LTD	Abstract	☒
	4	1573672	CN	A	2005-02-02	SAMSUNG ELECTRONICS CO LTD		☐
	5	1971310	CN	A	2007-05-30	SAMSUNG ELECTRONICS CO LTD	Abstract	☒
	6	1971310	CN	A	2007-05-30	SAMSUNG ELECTRONICS CO LTD		☐
	7	100440313	CN	C	2008-12-03	HILLCREST LAB INC	Abstract	☐
	8	100440313	CN	C	2008-12-03	HILLCREST LAB INC		☐
	9	101078957	CN	A	2007-11-28	SAMSUNG ELECTRONICS CO LTD	Abstract	☒
	10	101078957	CN	A	2007-11-28	SAMSUNG ELECTRONICS CO LTD		☐
	11	101173858	CN	A	2008-05-07	BEIJING CONTROL ENGINEERING IN	Abstract	☒
	12	101173858	CN	A	2008-05-07	BEIJING CONTROL ENGINEERING IN		☐

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	13	101256456	CN	A	2008-09-03	HILLCREST COMM INC	Abstract	☒
	14	101256456	CN	A	2008-09-03	HILLCREST COMM INC		☐
	15	101377722	CN	A	2009-03-04	IND TECH RES INST	Abstract	☒
	16	101377722	CN	A	2009-03-04	IND TECH RES INST		☐
	17	101427570	CN	A	2009-05-06	HILLCREST LAB INC	Abstract	☒
	18	101427570	CN	A	2009-05-06	HILLCREST LAB INC		☐
	19	101472095	CN	A	2009-07-01	PIXART IMAGING INC	Abstract	☒
	20	101472095	CN	A	2009-07-01	PIXART IMAGING INC		☐
	21	101606120	CN	A	2009-12-16	SONY CORP	Abstract	☒
	22	101606120	CN	A	2009-12-16	SONY CORP		☐
	23	101726295	CN	A	2010-06-09	CHINESE ACAD INST AUTOMATION	Abstract	☒

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	24	101726295	CN	A	2010-06-09	CHINESE ACAD INST AUTOMATION		☐
	25	101788860	CN	A	2010-07-28	YUANZHAN TECHNOLOGIES CO LTD	Abstract	☒
	26	101788860	CN	A	2010-07-28			☐
	27	101872259	CN	A	2010-10-27	SECOND ARTILLERY ENGINEERING UNIVERSITY OF THE CHI	Abstract	☒
	28	101872259	CN	A	2010-10-27	SECOND ARTILLERY ENGINEERING UNIVERSITY OF THE CHI		☐
	29	101915580	CN	A	2010-12-15	CHINESE ACAD INST AUTOMATION	Abstract	☒
	30	101915580	CN	A	2010-12-15	CHINESE ACAD INST AUTOMATION		☐
	31	102778965	CN	B	2017-04-12	BRITISH VIRGIN ISLANDS CYWEE CO LTD		☐
	32	201514612	CN	U	2010-06-23	JIANKANG WU	Abstract	☒
	33	201514612	CN	U	2010-06-23	JIANKANG WU		☐
	34	1 731 996	EP	A2	2006-12-13	ZHANG GUANGLIE; SHI GUANGYI; LUO YILUN; et al.		☐

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	35	2007-183138	JP	A	2007-07-19	NONAMI KENZO; SHIN SHIN; SUZUKI SATOSHI; NAKAZAWA	Abstract	☒
	36	2007-183138	JP	A	2007-07-19	NONAMI KENZO; SHIN SHIN; SUZUKI SATOSHI; NAKAZAWA		☐
	37	10-2009-0106767	KR	A	2009-10-12	LG ELECTRONICS INC	Abstract	☒
	38	10-2009-0106767	KR	A	2009-10-12	LG ELECTRONICS INC		☐
	39	10-2010-0091854	KR	A	2010-08-19	LG ELECTRONICS INC	Abstract	☒
	40	10-2010-0091854	KR	A	2010-08-19	LG ELECTRONICS INC		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

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.	T5
	1	Chinese language office action dated 2019-05-15, issued in application no. CN 201210084834.6.	
	2	Chinese language office action dated 2019-05-16, issued in application no. CN 201210084834.6.	
	3	Chinese language office action dated 2019-05-17, issued in application no. CN 201210084834.6.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

	4	Chinese language document; 2009; pps. 486-659	
	5	Chinese language document; 2015; pps. 242-659	
	6	Chinese language office action dated 2020-01-03, issued in application no. 201710093370.8.	
	7	Chinese language office action dated 2019-04-25, issued in application no. 201710093370.8.	
	8	Azuma, Ronald et al. Improving Static and Dynamic Registration in an Optical See-Through HMO. Proceedings of SIGGRAPH '94 (Orlando, Fla., 24 29 Jul., 1994), Computer Graphics, Annual Conference Series, 1994, 197 204.	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/BRYAN EARLES/	Date Considered	12/04/2021

*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.

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number	
	Filing Date	2020-11-20
	First Named Inventor	Shun-Nan LIOU, et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	250303-1022

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	/M.PaulQualey,Jr./	Date (YYYY-MM-DD)	2020-11-20
Name/Print	M. Paul Qualey Jr.	Registration Number	43,024

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.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

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 the Freedom of Information Act requires disclosure of these record s.

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 inspections 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.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /BE/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

109673 7590 02/22/2022

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 550
Atlanta, GA 30339

EXAMINER	
EARLES, BRYAN E	

ART UNIT	PAPER NUMBER
2625	

NOTIFICATION DATE	DELIVERY MODE
02/22/2022	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):

callie.reynolds@mqrlaw.com
dan.mcclure@mqrlaw.com
uspatents@mqrlaw.com

PTOL-90A (Rev. 04/07)

Applicant-Initiated Interview Summary	**Application No.** 16/953,771	**Applicant(s)** LIOU et al.		
	Examiner BRYAN EARLES	**Art Unit** 2625	**AIA (First Inventor to File) Status** No	**Page** 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	**Title**	**Type**
BRYAN EARLES	Primary Examiner	Telephonic
Paul M. Qualey, Jr.	Attorney of Record	

Date of Interview: 16 February 2022

Issues Discussed:

35 U.S.C. 103

Discussed Applicant's proposed amendment to independent claims 1 and 15 (see Agenda) in relation to the currently cited combination of prior art. This amendment appears to overcome the teachings of Bachmann, however, further consideration is required prior to making a definitive determination. No decision has been reached at this time regarding patentability.

☑ Attachment

/BRYAN EARLES/ Primary Examiner, Art Unit 2625	

Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:

Shun-Nan LIOU, et al.

Serial No.: 16/953,771

Filed: November 20, 2020

For: Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof

Confirmation No.: 1038

Group Art Unit: 2625

Examiner: Earles, Bryan E.

Docket No.: 250303-1022

AGENDA

For the telephone interview scheduled for Wednesday, 16 February 2022 at 10AM, Applicant would like to discuss the following in regards to the prior art. In particular, it appears that Bachmann teaches the use of measurements that are then weighted based on time relevance in order to compute an error correction. This appears to be unlike the concept embodied in Applicant's claim 1, for example, which determines predicted axial accelerations based on a previous quaternion and then uses the predicted axial accelerations (not measured) and measured axial accelerations to obtain a first comparison result (error correction).

In order to further clarify this distinction, the following amendment is proposed for claim 1:

> 1. (PROPOSED) An electronic device subject to movements and rotations in a spatial reference frame, comprising:
>
> a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by:

providing a previous quaternion corresponding to time T-1 based on [[the]] measured axial accelerations corresponding to time T-1 and [[the]] measured angular velocities corresponding to time T-1;

converting [[the]] measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion corresponding to time T and predicted axial accelerations corresponding to time T;

comparing the predicted axial accelerations with [[the]] measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

~~, and~~ using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

Similar amendments are proposed for independent claim 15.

Please do not hesitate to contact the undersigned by phone (678-483-8899).

Respectfully submitted,

/M.PaulQualey,Jr./

By: _____

M. Paul Qualey, Jr.
Registration No. 43,024

Customer No. 109673

Electronic Acknowledgement Receipt	
EFS ID:	45122468
Application Number:	16953771
International Application Number:	
Confirmation Number:	1038
Title of Invention:	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF
First Named Inventor/Applicant Name:	Shun-Nan LIOU
Customer Number:	109673
Filer:	Michael P. Qualey/Brooke French
Filer Authorized By:	Michael P. Qualey
Attorney Docket Number:	250303-1022
Receipt Date:	02-MAR-2022
Filing Date:	20-NOV-2020
Time Stamp:	09:15:11
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	Amendment/Request for Reconsideration-After Non-Final Rejection	00953783.PDF	148394 6a40f4584f604c72222bb42d2540e9e7f232e06c	no	15

Warnings:

Information:	
Total Files Size (in bytes):	148394

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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:

Shun-Nan LIOU, et al.

Serial No.: 16/953,771

Filed: November 20, 2020

For: Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof

Confirmation No.: 1038

Group Art Unit: 2625

Examiner: Earles, Bryan E.

Docket No.: 250303-1022

AMENDMENT AND RESPONSE TO NON-FINAL OFFICE ACTION

Mail Stop: Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Director:

The outstanding Non-Final Office Action mailed 8 December 2021, has been carefully considered. In response thereto, please enter the following amendments and remarks. Reconsideration and allowance of the application and presently pending claims, as amended, are respectfully requested.

AMENDMENTS

In the Claims

1. (Currently Amended) An electronic device subject to movements and rotations in a spatial reference frame, comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting the measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T;

obtaining [[and]] predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;

comparing the predicted axial accelerations with [[the]] measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

~~, and~~ using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

2. (Original) The electronic device of claim 1, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame.

3. (Original) The electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

4. (Original) The electronic device of claim 1, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

5. (Original) The electronic device of claim 1, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

6. (Canceled)

7. (Original) The electronic device of claim 1, wherein the content is visual content.

8. (Original) The electronic device of claim 7, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

9. (Original) The electronic device of claim 8, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

10. (Original) The electronic device of claim 1, wherein:

the motion sensor module further comprises a magnetometer having magnetometer circuitry configured to generate measured magnetisms; and

in calculating the resulting deviation, the computing processor is further configured to:

convert the measured magnetisms corresponding to time T to a measured yaw angle and convert the angular velocities corresponding to time T to a predicted yaw angle;

compare the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtain the updated quaternion based on the second comparison result.

11. (Original) The electronic device of claim 10, wherein:

the measured yaw is based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

12. (Original) The electronic device of claim 10, wherein, in calculating the resulting deviation, the computing processor is further configured to:

obtain a first updated quaternion based on the current quaternion and the first comparison result; and

obtain a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

13. (Original) The electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtain the updated quaternion in response to determining that the compensation is needed.

14. (Original) The electronic device of claim 13, wherein, in calculating the resulting deviation, the computing processor is further configured to utilize the first data association model to determine whether compensation is needed to obtain the updated quaternion based on

whether the first comparison result is a first predetermined value or within a first predetermined range.

15. (Currently Amended) A method for determining movements and rotations in a spatial reference frame, comprising:

generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;

calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting the measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T;

obtaining [[and]] predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;

comparing the predicted axial accelerations with [[the]] measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

~~, and~~ using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion; and

providing content based on the resulting deviation in the spatial reference frame.

16. (Original) The method of claim 15, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of an electronic device in a spatial reference frame.

17. (Original) The method of claim 15, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

18. (Original) The method of claim 15, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

19. (Original) The method of claim 15, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

20. (Canceled)

21. (Original) The method of claim 15, wherein the content is visual content.

22. (Original) The method of claim 21, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

23. (Original) The method of claim 22, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

24. (Original) The method of claim 15, wherein:

the method further comprises generating, with a magnetometer having magnetometer circuitry, measured magnetism; and

calculating the resulting deviation further comprises:

converting the measured magnetisms corresponding to time T to a measured yaw angle and converting the angular velocities corresponding to time T to a predicted yaw angle;

comparing the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtaining the updated quaternion based on the second comparison result.

25. (Original) The method of claim 24, wherein:

the measured yaw is calculated and obtained based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

26. (Original) The method of claim 24, wherein calculating the resulting deviation further comprises:

obtaining a first updated quaternion based on the current quaternion and the first comparison result; and

obtaining a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

27. (Original) The method of claim 15, wherein calculating the resulting deviation further comprises:

utilizing a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtaining the updated quaternion in response to determining that the compensation is needed.

28. (Original) The method of claim 27, wherein calculating the resulting deviation further comprises utilizing the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range.

REMARKS

The Examiner is thanked for the thorough examination of the present application. The Office Action, however, tentatively rejected claims 1 - 28. In response, Applicant respectfully submits the foregoing amendments, in which claims 1 and 15 are amended, and claims 6 and 20 are canceled without waiver, disclaimer or prejudice. Reconsideration of this application, as amended, is respectfully requested.

Telephone Interview

The Examiner is thanked for the time spent discussing the application with the undersigned on 16 February 2022. Although no specific agreement was reached, it is believed that the amended claims presented herein define over the cited art.

Claim Rejections - 35 USC § 103

The Office Action indicates that claims 1-28 are rejected under 35 U.S.C. 103 as allegedly being unpatentable over Yamashita, et al. (U.S. 8,267,785, hereinafter "Yamashita") in view of Bachmann, et al. (U.S. 7,089,148, hereinafter, "Bachmann"). With respect to claims 6 and 20, Applicant respectfully asserts that the rejection has been rendered moot. With respect to the remaining claims, Applicant respectfully traverses the rejection for at least the reasons described below.

Additionally, Applicant respectfully notes that the final decision in IPR2019-00143 (for related U.S. Patent 8,441,438) held several claims unpatentable; however, the features described below in support of patentablility in the instant application appear unique and distinct from the

conclusions in that matter. Independent assessment by the Office of the conclusions in the IPR are recommended.

Independent Claim 1 is Allowable

Claim 1, as amended, recites:

> 1. An electronic device subject to movements and rotations in a spatial reference frame, comprising:
> a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and
> a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by:
> providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;
> ***converting the measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T;***
> ***obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;***
> ***comparing the predicted axial accelerations with measured axial accelerations corresponding to time T to obtain a first comparison result;***
> ***obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;***
> using the updated quaternion as a next occurrence of the previous quaternion; and
> providing the resulting deviation based on the updated quaternion;
> wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

(Emphasis Added).

Applicant respectfully assets that the cited art is legally deficient for rendering claim 1 unpatentable. In particular, the cited art (either individually or in combination) does teach or reasonably suggest at least the features emphasized above in claim 1.

With respect to the pending rejection, the cited art does not appear to be involved with the various quaternions and the associated times (e.g., time T, time T-1) as recited in claim 1, or with the comparing of predicted axial accelerations and measured axial accelerations, both of which correspond to time T. Of significance, "measured angular velocities corresponding to time T" is recited in several features in claim 1 (i.e., "converting the measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T"; and "obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion"). Bachmann does not appear to teach or reasonably suggest the use of measured angular velocities corresponding to time T in these distinct manners. Support for these features may be found at various portions of the application as originally filed, such as at paragraphs [0054] and [0055] of the published application. Therefore, no new matter is added.

Additionally, these relationships are informative as to the particularities of the comparing limitation of the recited computer processor, which involves "comparing the predicted axial accelerations with measured axial accelerations corresponding to time T to obtain a first comparison result". Thus, the "predicted axial accelerations" (corresponding to time T) are compared with measured axial accelerations corresponding to time T. Bachmann also does not appear to teach or reasonably suggest such a comparison.

Thereafter, an updated quaternion associated with time T is obtained, with the updated quaternion being based on the current quaternion and the first comparison result. Once again, Bachmann does not appear to teach or reasonably suggest this feature. The secondary references are unable to remedy the deficiencies of Bachmann.

Based on the above, Applicant respectfully asserts that claim 1 is in condition for allowance.

Independent Claim 15 is Allowable

Claim 15, as amended, recites:

> 15. A method for determining movements and rotations in a spatial reference frame, comprising:
> generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;
> calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by:
> providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;
> ***converting the measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T;***
> ***obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;***
> ***comparing the predicted axial accelerations with measured axial accelerations corresponding to time T to obtain a first comparison result;***
> ***obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;***
> ***using the updated quaternion as a next occurrence of the previous quaternion;*** and
> providing the resulting deviation based on the updated quaternion; and
> providing content based on the resulting deviation in the spatial reference frame.

(Emphasis Added).

Applicant respectfully assets that the cited art is legally deficient for rendering claim 15 unpatentable. In particular, the cited art (either individually or in combination) does teach or reasonably suggest at least the features emphasized above in claim 15.

With respect to the pending rejection, the cited art does not appear to be involved with the various quaternions and the associated times (e.g., time T, time T-1) as recited in claim 15, or with the comparing of predicted axial accelerations and measured axial accelerations, both of which correspond to time T. Of significance, "measured angular velocities corresponding to time T" is recited in several features in claim 15 (i.e., "converting the measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T"; and "obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion"). Bachmann does not appear to teach or reasonably suggest the use of measured angular velocities corresponding to time T in these distinct manners. Support for these features may be found at various portions of the application as originally filed, such as at paragraphs [0054] and [0055] of the published application. Therefore, no new matter is added.

Additionally, these relationships are informative as to the particularities of the comparing limitation of the comparing step, which involves "comparing the predicted axial accelerations with measured axial accelerations corresponding to time T to obtain a first comparison result". Thus, the "predicted axial accelerations" (corresponding to time T) are compared with measured axial accelerations corresponding to time T. Bachmann also does not appear to teach or reasonably suggest such a comparison.

Thereafter, an updated quaternion associated with time T is obtained, with the updated quaternion being based on the current quaternion and the first comparison result. Once again, Bachmann does not appear to teach or reasonably suggest this feature. The secondary references are unable to remedy the deficiencies of Bachmann.

Based on the above, Applicant respectfully asserts that claim 15 is in condition for allowance.

Dependent Claims are Allowable

Applicant respectfully asserts that the pending dependent claims are allowable fo9r incorporating the features of their respective independent claims. Additionally, these claims recite other features that may serve as independent bases for patentability.

CONCLUSION

Favorable reconsideration and allowance of the present application and all pending claims are hereby courteously requested.

Should the Examiner feel that further discussion of the application is conducive to prosecution and allowance thereof, please do not hesitate to contact the undersigned by phone (678-483-8899).

No fee is believed to be due in connection with this submission other than those, which may have already been provided. If, however, any fee is believed to be due, you are hereby authorized to charge any such fee to deposit account No. 50-5954.

Respectfully submitted,

/M.PaulQualey,Jr./

By: _____

M. Paul Qualey, Jr.
Registration No. 43,024

Customer No. 109673

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

109673 7590 03/21/2022

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 550
Atlanta, GA 30339

EXAMINER	
EARLES, BRYAN E	

ART UNIT	PAPER NUMBER
2625	

NOTIFICATION DATE	DELIVERY MODE
03/21/2022	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):

callie.reynolds@mqrlaw.com
dan.mcclure@mqrlaw.com
uspatents@mqrlaw.com

PTOL-90A (Rev. 04/07)

Office Action Summary	**Application No.** 16/953,771	**Applicant(s)** LIOU et al.	
	Examiner BRYAN EARLES	**Art Unit** 2625	**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 02 March 2022.

☐ 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) 1-5,7-19 and 21-28 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) 1-5,7-19 and 21-28 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 _____ 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 _____.

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

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

The Office acknowledges the amendment dated 02 March 2022, in which:

Claims **1-5, 7-19 and 21-28** are currently pending.

Claims **1 and 15** are amended.

Claims **6 and 20** are canceled.

Claim Rejections - 35 USC § 103

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.

Claims 1-5, 7-19 and 21-28 are rejected under 35 U.S.C. 103 as being unpatentable over Yamashita et al. (US 8,267,785, hereinafter "Yamashita") in view of Bachmann et al. (US 7,089,148, hereinafter "Bachmann").

With respect to **claim 1** (Currently Amended), Yamashita teaches an electronic device subject to movements and rotations in a spatial reference frame (Yamashita: Fig. 1-3), comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations (Yamashita: Fig. 7, gyrosensor unit 7 includes gyrosensors 55 and 56 for producing tri-axial angular velocity data).

Yamashita fails to expressly disclose:

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

However, Bachmann discloses:

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic

device in the spatial reference frame (Bachmann: Fig. 3, the angular rates (p, q, r) at box 33 correspond to measured movements and rotations in a sensor reference frame) by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1 (Bachmann: Fig. 3, the previous quaternion corresponds to the prior orientation output quaternion at 39);

converting the measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T (Bachmann: Fig. 3, the angular rates at box 33 are converted at box 37 to a rate quaternion);

obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion; (Bachmann: Fig. 3, computed measurement vector $\overline{y}(\hat{q})$ (box 35a) is the predicted axial acceleration and magnetic orientation quaternion based on the measured angular velocities; rate quaternion $\dot{q}$ is the "current quaternion" representing the "current state"; $\overline{yo}$ $(\hat{q})$ represents the current measured values for these quantities, and $\overline{y}(\hat{q})$ represents the same quantities derived from the prior predicted state);

comparing (Paragraph [0004], of Applicant's Specification, "The term of "comparison" of the present invention may generally refer to the calculating and obtaining of the actual deviation angles of the 3D pointing device ...") the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result (Bachmann: Fig. 3, the comparison occurs at the junction between boxes 34 and 35, such that the filter chooses a correction factor, that

when added to q.dot., will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values);

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion (Bachmann: Fig. 3, the updated quaternion is a new value of the orientation output quaternion at 39); and

providing the resulting deviation based on the updated quaternion (Bachmann: Fig. 3, the updated quaternion reflects the correction factor using predicted measurements based on the previous orientation output quaternion);

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame (Bachmann: Fig. 4, processing unit translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

Therefore, it would be obvious to one of ordinary skill in the art at the time the invention was made to modify the method, as taught by Yamashita, to incorporate additional types of detectors into the motion sensing module, as taught by Bachmann, in order overcome the shortcomings of individual detector types by capitalizing on the advantages of each (Bachmann: Col. 4, lines 15-30, Col. 13, lines 1-10).

With respect to **claim 2**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer (Yamashita: Fig. 7, gyrosensor unit 7 and acceleration sensor 37);

the rotation sensor has sensor circuitry configured to generate the measured angular velocities (Yamashita: Fig. 7, gyrosensor unit 7 includes gyrosensors 55 and 56 for producing tri-axial angular velocity data);

the accelerometer has circuitry configured to generate the measured axial accelerations (Yamashita: Fig. 7; Col. 12, line 47 – Col. 13, line 10, output from the acceleration sensor 37 represented as a three-dimensional acceleration vector (ax,ay,az));

and both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame (Yamashita: Fig. 7; Col. 12, line 47 – Col. 13, line 10, output from the acceleration sensor 37 represented as a three-dimensional vector (ax,ay,az) in a XYZ coordinate system).

With respect to **claim 3**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T (Bachmann: Fig. 3, the angular rates at box 33 are converted at box 37 to a rate quaternion).

With respect to **claim 4** the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T (Bachmann: Fig. 3, an estimated

orientation quaternion 39 is correlated with the measurement vector 34 and the angular rate information 37; Col. 16, line 40 – Col. 17, line 5, each iteration computes an updated estimated quaternion representative of a new estimate of sensor orientation).

With respect to **claim 5**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T (Bachmann: Fig. 3, the comparison occurs at the junction between boxes 34 and 35, such that the filter chooses a correction factor, that when added to q.dot., will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values).

With respect to **claim 7**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein the content is visual content (Bachmann: Fig. 4, Col. 13, lines 20-30).

With respect to **claim 8**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 7, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame (Bachmann: Fig. 4, processing unit translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

With respect to **claim 9**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 8, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern (Bachmann: Fig. 4, processing unit translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

With respect to **claim 10**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein:

the motion sensor module further comprises a magnetometer having magnetometer circuitry configured to generate measured magnetisms (Bachmann: Fig. 3, magnetometers 38 generate measured magnetisms b1, b2, b3); and

in calculating the resulting deviation, the computing processor is further configured to:

convert the measured magnetisms corresponding to time T to a measured yaw angle (Bachmann: Fig. 3, box 32 outputs measured magnetisms b1, b2, b3 corresponding to yaw pitch and roll angles) and convert the angular velocities corresponding to time T to a predicted yaw angle (Bachmann: Fig. 3, box 33 outputs signal (p, q, r) comprising angular velocities Ωx, Ωy, Ωz. used to calculate each output $\hat{q}$ and are therefore a part of each orientation output quaternion q);

compare the predicted yaw angle with the measured yaw angle to obtain a second comparison result (Bachmann: Fig. 3, measured magnetisms are compared with respective predicted magnetisms in the computed measurement vector 35a to obtain a six-valued error vector 36 that corresponds to measure of how actual

accelerometer and magnetometer measurements differ from the what the filter predicts those measurements should be, based on the angular rate sensor output (Bachmann: Fig. 3, the filter selects a correction factor output at box 41 that when added to the output at box 37 will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values); and

obtain the updated quaternion based on the second comparison result (Bachmann: Fig. 3, the filter selects a correction factor output at box 41 that when added to the output at box 37 will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values).

With respect to **claim 11**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 10, wherein:

the measured yaw is based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion (Bachmann: Fig. 3, includes intermediate sensor orientations represented in the form of quaternions (e.g., old and new q.sub.circumflex); Col. 7, lines 4-31; transforming estimated body rates to updated Euler Rates or Quaternion Rates).

With respect to **claim 12**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 10, wherein, in calculating the resulting deviation, the computing processor is further configured to:

obtain a first updated quaternion based on the current quaternion and the first comparison result (Bachmann: Fig. 3, an estimated orientation quaternion 39 is correlated with the measurement vector 34 and the angular rate information 37; Col. 16, line 40 – Col. 17, line 5, each iteration computes an updated estimated quaternion representative of a new estimate of sensor orientation); and

obtain a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion (Bachmann: Col. 9, lines 22-32; Fig. 3, a second updated state is interpreted as a subsequent iteration using the previously updated state; Equation 16).

With respect to **claim 13**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtain the updated quaternion in response to determining that the compensation is needed (Bachmann: Fig. 3; performing compensation if the error vector yields a non-zero result, then no deviation exist in the subtracting operation between the actual

measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values then no compensation is performed).

With respect to **claim 14**, the combination of Yamashita as modified by Bachmann teaches the electronic device of claim 13, wherein, in calculating the resulting deviation, the computing processor is further configured to utilize the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range (Bachmann: Fig. 3; performing the compensation only if the error vector yields a non-zero result, otherwise if no deviation exist in the subtracting operation between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values, then no compensation is performed).

Method claims (15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27 & 28) are drawn to the method of using the corresponding apparatus claimed in claims (1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13 & 14). Therefore, method claims (15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27 & 28) correspond to apparatus claims (1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13 & 14) and are rejected for the same reasons of obviousness as used above.

Response to Arguments/Amendments/Remarks

Applicant's arguments with respect to claims 1-5, 7-19 and 21-28 have been fully considered but are not persuasive.

Based on the Termination Decision (Attached), at pages 70-72, the limitation, "obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion" is obvious over the combination of Yamashita as modified by Bachmann. Bachmann discloses that the computed measurement vector $\overline{y}(\hat{q})$ (box 35a) as the predicted axial acceleration and magnetic orientation quaternion based on the measured angular velocities; rate quaternion $\dot{q}$ is the "current quaternion" representing the "current state"; $\overline{yo}$ $(\hat{q})$ represents the current measured values for these quantities, and $\overline{y}(\hat{q})$ represents the same quantities derived from the prior predicted state. As such, the rejection of claims 1-5, 7-19 and 21-28 as being unpatentable over the combination of Yamashita as modified by Bachmann is maintained.

Conclusion

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.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to BRYAN EARLES whose telephone number is (571)272-4628. The examiner can normally be reached on Monday - Thursday at 7:30am - 5:00pm.

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, William Boddie can be reached on 571-272-0666. 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.

/BRYAN EARLES/
Primary Examiner, Art Unit 2625

Trials@uspto.gov
571-272-7822

Paper 87
Date: February 17, 2021

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZTE (USA), INC. and LG ELECTRONICS INC.,
Petitioner,

v.

CYWEE GROUP LTD.,
Patent Owner.

IPR2019-00143
Patent 8,441,438 B2

Before KEVIN F. TURNER, PATRICK M. BOUCHER, and CHRISTOPHER L. OGDEN, *Administrative Patent Judges.*

OGDEN, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
Denying Patent Owner's Motion to Amend
35 U.S.C. § 318(a)

I. INTRODUCTION

In response to a Petition (Paper 1, "Pet.") by ZTE (USA), Inc. ("ZTE"),[1] the Board instituted an *inter partes* review of claims 1, 4, 5, 14–17, and 19 of U.S. Patent No. 8,441,438 B2 (Ex. 1001, "the '438 patent"). Paper 7. CyWee Group Ltd. ("CyWee"),[2] the Patent Owner, filed a Patent Owner Response (Paper 18, "PO Resp."), ZTE filed a Reply to the Patent Owner Response (Paper 33, "ZTE Reply"), and CyWee filed a Sur-reply (Paper 37, "PO Sur-reply").

CyWee also filed a contingent Motion to Amend proposing a set of substitute claims if we find the original claims unpatentable. Paper 19 ("MTA"). ZTE filed an Opposition to this Motion to Amend, Paper 34, and we issued Preliminary Guidance under the Board's Motion to Amend Pilot Program. Paper 35.

After we issued our Preliminary Guidance, we determined that a separate petition by LG Electronics Inc. ("LGE")[3] had met the requirements for instituting an *inter partes* review in *LG Electronics Inc., v. CyWee Group Ltd.*, IPR2019-01203, Paper 12 (PTAB Dec. 17, 2019); Paper 36 (same decision filed in this case). So we joined LGE to this proceeding under 35 U.S.C. § 315(c). Paper 36, 45–49. We noted that LGE had agreed to act

---

[1] ZTE identifies ZTE (USA), Inc. and ZTE Corporation as the real parties in interest. Pet. 2.

[2] CyWee identifies CyWee Group Ltd. as the real party in interest. Paper 5, 2.

[3] LGE identifies LG Electronics Inc. and LG Electronics U.S.A., Inc. as the real parties in interest. IPR2019-01203, Paper 2, 1. LGE also "further identifies" ZTE (USA), Inc. and ZTE Corporation as real parties in interest. *Id.*

in a passive "understudy" role, and would not assume an active role unless ZTE ceased to participate in the *inter partes* review. *Id.* at 46.

Thereafter, CyWee filed a contingent Revised Motion to Amend, which included a different set of proposed substitute claims. Paper 38 ("RMTA"). ZTE submitted an Opposition stating that "[b]ased on the Board's Preliminary Guidance and Patent Owner's Revised Motion to Amend, petitioner withdraw[s] all objections to the revised amended claims and hence, [ZTE] does not challenge the patentability of the revised amended claims. [ZTE] therefore does not oppose Patent Owner's Revised Motion to Amend." Paper 41, 1–2.

LGE then requested permission to file its own Opposition to the Revised Motion to Amend, which we initially denied, but granted on rehearing. Paper 50. We held that LGE may "present arguments and evidence, independently from ZTE, in response to CyWee's Revised Motion to Amend," but "limited solely to the issues raised in CyWee's Revised Motion to Amend." *Id.* at 9; *but see id.* at 5 (Boucher, J., dissenting) ("We should hold LGE to limitations it freely imposed upon itself, and upon which CyWee appears to have relied."). LGE then filed an Opposition to the Revised Motion to Amend. Paper 62 ("Opp. RMTA").

We held an oral hearing on November 18, 2020, and the transcript is entered on the record. Paper 84 ("Tr."). At the hearing, the parties addressed only the proposed substitute claims in the Revised Motion to Amend, and not the grounds of the Petition. *See* Tr. 6:2–8.

This is a Final Written Decision under 35 U.S.C. § 318(a) as to whether the claims challenged in the *inter partes* review are patentable and as to the merits of CyWee's Revised Motion to Amend. ZTE has shown, by

a preponderance of the evidence on the record before us, that claims 1, 4, 5, 14–17, and 19 of the '438 patent are unpatentable. LGE has shown, by a preponderance of the evidence, that proposed substitute claims 20–24 are unpatentable and we determine that proposed substitute claims 21 and 24 add new matter, so we also deny CyWee's Revised Motion to Amend.

II. BACKGROUND

A. RELATED PROCEEDINGS

The parties identify the following as related district court cases: *CyWee Group Ltd. v. ZTE (USA) Inc.*, No. 3:17-cv-02130 (S.D. Cal.); *CyWee Group Ltd. v. Google, Inc.*, No. 1:18-cv-00571 (D. Del.); *CyWee Group Ltd. v. HTC Corporation et al.*, No. 2:17-cv-00932 (W.D. Wash.); *CyWee Group Ltd. v. Motorola Mobility LLC*, No. 1:17-cv-00780 (D. Del.); *CyWee Group Ltd. v. Huawei Technologies Co., Inc. et al.*, No. 2:17-cv-00495 (E.D. Tex.); *CyWee Group Ltd. v. LG Electronics, Inc. et al.*, Case No. 3:17-cv-01102, (S.D. Cal.); and *CyWee Group Ltd. v. Samsung Electronics Co. Ltd. et al.*, No. 2:17-cv-00140 (E.D. Tex.); *CyWee Group Ltd. v. Apple Inc.*, No. 4:14-cv-01853 (N.D. Cal.). Pet. 2–3; Paper 5, 2–3.

The Board has also issued a final written decision involving the '438 patent in *Google LLC v. CyWee Group Ltd.*, No. IPR2018-01258, Paper 86 (PTAB Jan. 9, 2020). Pet. 3; Paper 5, 3. In this decision, the Board concluded that claims 1 and 3–5 of the '438 patent are unpatentable, and the Board denied CyWee's motion to amend. IPR2018-01258, Paper 86 at 116.

B. THE '438 PATENT (EX. 1001)

The '438 patent issued from U.S. Patent Application No. 12/943,934 ("the '934 application"), which has a filing date of November 11, 2010. Ex. 1001, codes (21), (22). It claims priority to U.S. Provisional Application No. 61/292,558 ("the '558 provisional application"), filed on January 6, 2010. *Id.* at code (60); 1:7–9.

The '438 patent "relates to a three-dimensional (3D) pointing device." Ex. 1001, 1:17–18. In describing the prior art, the inventors discuss the function of a general 3D pointing device, as shown in Figure 1, reproduced below:

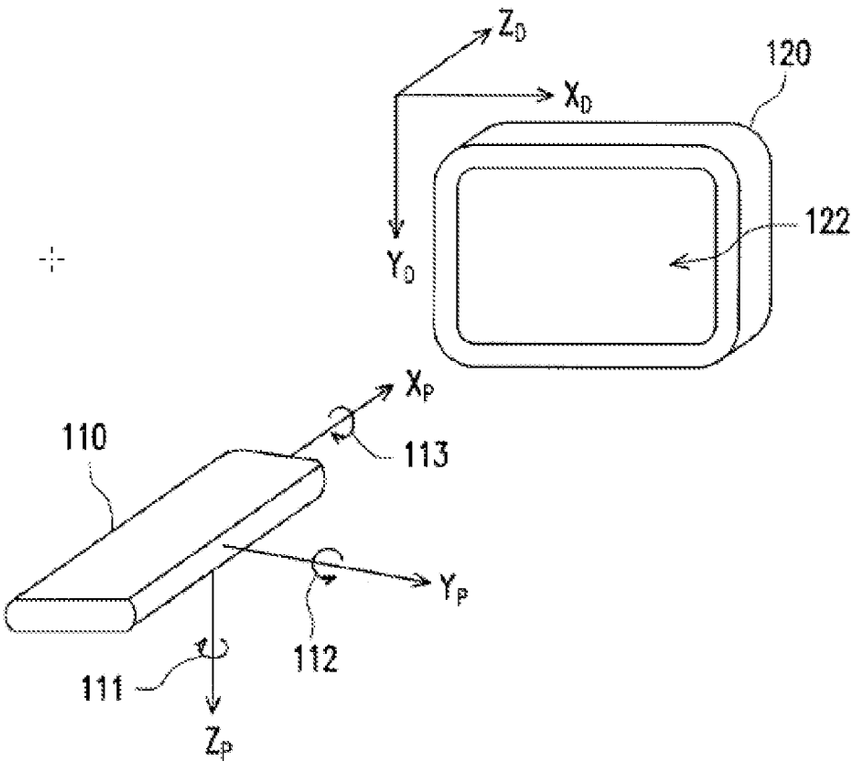


FIG. 1 (RELATED ART)

Figure 1 is a schematic diagram depicting prior-art handheld 3D pointing device 110. Ex. 1001, 1:28–29. A user may point it at screen 122 of display device 120 to perform control actions. *Id.* at 1:29–30, 1:48–51. Figure 1 shows sets of axes representing two different reference frames: a "spatial pointer reference frame" associated with pointing device 110, and a "display frame" associated with display device 120. *Id.* at 1:35–38. The spatial pointer reference frame is defined by coordinate axes X_P, Y_P, and Z_P, while the display frame is defined by coordinate axes X_D, Y_D, and Z_D. *Id.* at 1:38–43.

The system keeps track of the orientation of pointing device 110 by measuring three deviation angles: yaw angle 111 representing the device's rotation about axis Z_P, pitch angle 112 representing its rotation about axis Y_P, and roll angle 113 representing its rotation about axis X_P. Ex. 1001, 1:58–2:2. The system may then perform "mapping" by translating the deviation angles in the spatial pointer reference frame onto the display frame. *Id.* at 2:33–37; *see also id.* at 2:3–22 (describing prior art examples of mapping).

The pointing device of the claimed invention performs such mapping using "a six-axis motion sensor module." Ex. 1001, 1:19–23. "Six-axis" means that the sensor module is "capable of detecting rotation rates or angular velocities of the 3D pointing device about all of the X_P, Y_P, and Z_P axes as well as axial accelerations of the 3D pointing device along all of the X_P, Y_P and Z_P axes." Ex. 1001, 4:62–65. Figure 4, reproduced below, is a schematic diagram of the pointing device's six-axis sensor module and other hardware components:

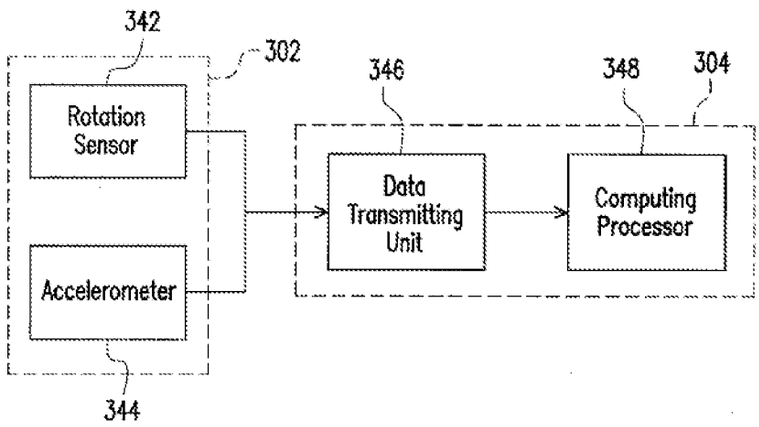


FIG. 4

Above, in Figure 4 of the '438 patent, dashed box 302 represents a "six-axis motion sensor module," which includes rotation sensor 342 and accelerometer 344. Ex. 1001, 7:59–61.[4] Dashed box 304 represents a "processing and transmitting module," which includes data transmitting unit 346 and computing processor 348. *Id.* at 7:61–63.

Figure 4 also includes arrows from rotation sensor 342 and accelerometer 344 to data transmitting unit 346 (depicting the flow of first and second "signal sets," respectively), and an arrow from data transmitting unit 346 to computer processor 348. *See id.* at 7:64–8:26. The first signal set includes "angular velocities ω_x, ω_y, and ω_z associated with the movements and rotations of the 3D pointing device" about the spatial pointer reference frame. *Id.* at 7:65–8:2. The second signal set includes "axial accelerations Ax, Ay, Az associated with the movements and rotations of the 3D pointing device . . . along each of the three orthogonal coordinate axes X_P Y_P Z_P of the spatial pointer reference frame." *Id.* at 8:4–8.

[4] CyWee states that the "six-axis sensor module . . . may consist of sensors known in the art." PO Resp. 3.

The sensors, and the method of calculating the deviation angles in the spatial pointer reference frame, produce errors and noise over time, and according to the '438 patent, an object of the claimed invention is to correct or eliminate the errors and noise. *See* Ex. 1001, 3:52–66; *id.* at 4:20–30. Thus, the pointing device of the claimed invention uses the first and second signal sets to compensate for accumulated errors, over time, in the device's estimation of its spatial orientation. *See id.*, Abstract, 1:17–26, 4:20–30.

A flowchart representing one embodiment of this compensation method is shown in Figure 7, reproduced below:

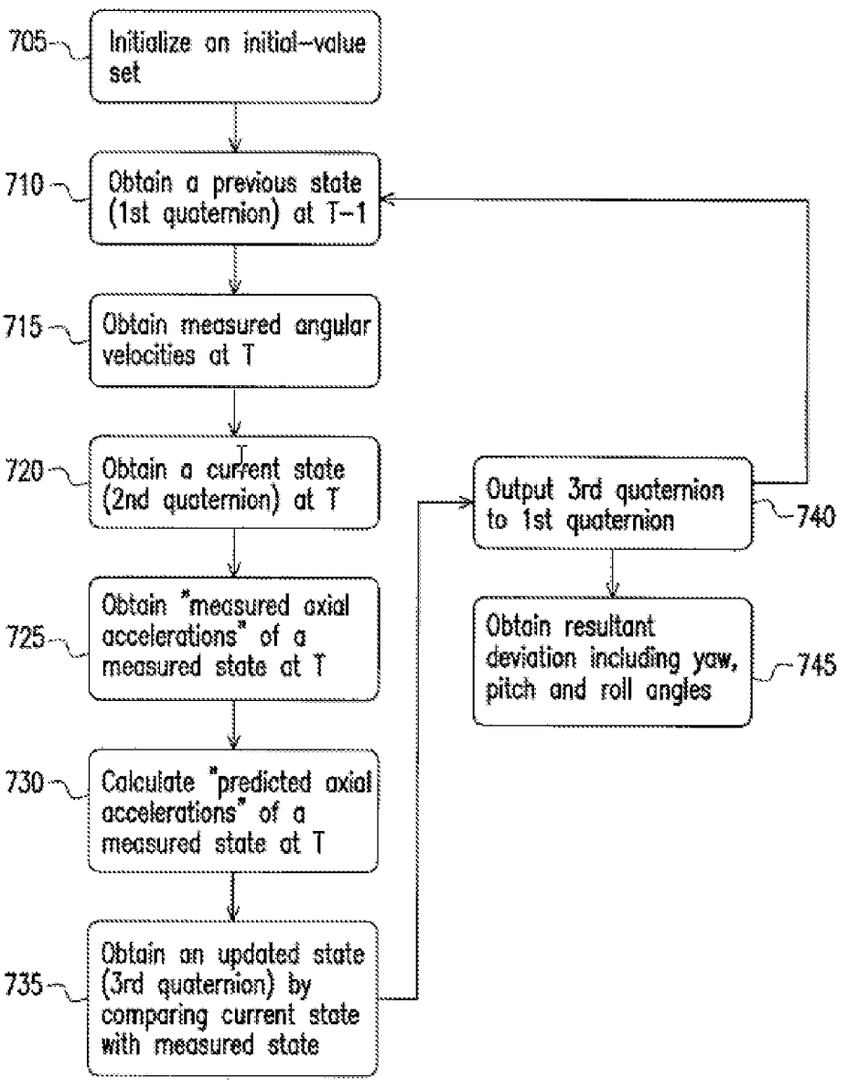


FIG. 7

The flowchart in Figure 7, above, depicts a method of calculating deviation angles of a 3D pointing device's special pointer reference frame. Ex. 1001, 10:42–47. The method starts with either initializing a new state or "obtaining a previous state of the six-axis motion sensor module (. . . steps 705, 710)."

Id. at 10:66–11:1. This state is in the form of "a first quaternion[5] associated with previous angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the six-axis motion sensor module at a previous time T−1." *Id.* at 11:2–4.

The method proceeds by "obtaining measured angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the six-axis motion sensor module at a current time T (. . . steps 715, 720)," to form a second quaternion representing the "current state." Ex. 1001, 11:6–8, 12:32–60. According to the '438 patent, one way to convert ω_x, ω_y, ω_z into the "second quaternion" is by using equation 1, below:

$$\begin{bmatrix}\dot{q}_0\\ \dot{q}_1\\ \dot{q}_2\\ \dot{q}_3\end{bmatrix} = \frac{1}{2}\begin{bmatrix}0 & -\omega_x & -\omega_y & -\omega_z\\ \omega_x & 0 & \omega_z & -\omega_y\\ \omega_y & -\omega_z & 0 & \omega_x\\ \omega_z & \omega_y & -\omega_x & 0\end{bmatrix}\begin{bmatrix}q_0\\ q_1\\ q_2\\ q_3\end{bmatrix}$$

Equation 1 is a differential equation with respect to quaternion (q_0, q_1, q_2, q_3), and the '438 patent suggests solving it using a data conversion utility. *See id.* at 12:40–60.

The method in Figure 7 then obtains the "measured state" of the six-axis motion sensor module in steps 725 and 730. Ex. 1001, 12:61–64. This measured state has two parts: a set of "measured axial accelerations Ax, Ay, Az" obtained from the accelerometer signals (step 725), and "predicted axial accelerations Ax′, Ay′, Az′," which are calculated based on the measured

[5] ZTE's declarant Scott Andrews explains that quaternions are four-dimensional extensions of complex numbers that "have the unique property of maintaining rotational relationships with relatively limited computational complexity." Ex. 1003 ¶ 41. CyWee does not dispute this explanation.

angular velocities (step 730). *Id.* at 11:10–15, 12:61–13:24. The predicted axial accelerations in step 730 are "calculated based on the . . . current state or second quaternion in relation to the measured angular velocities thereof." *Id.* at 13:11–13.[6]

Next, in step 735, the algorithm obtains a "third quaternion," representing an "updated state," by comparing the current state with the measured state. *Id.* at 11:15–18, 13:25–14:34. It does this by using a "comparison model" involving equations 5–11. In testimony that we find persuasive, CyWee's expert Professor LaViola characterizes equations 5–10 as extended Kalman filter equations, which were known in the art, and describes equation 11 as an error minimization. Ex. 2021 ¶ 46. He states that in the general framework of an extended Kalman filter, equations 5–10 represent a process model (equation 5)[7] and its corresponding covariance

---

[6] The '438 patent includes equations for calculating axial accelerations in terms of second quaternion (q_0, q_1, q_2, q_3), but the symbols for axial accelerations in these equations are Ax, Ay, and Az rather than the primed symbols Ax′, Ay′, and Az′. *See* Ex. 1001, 13:18–23 (equations 2–4). CyWee contends that a person of ordinary skill in the art would have understood that the absence of primes in these equations was a typographical error, and that the equations refer to the predicted axial accelerations. Reply RMTA 7. LGE contests this. *See* Opp. RMTA 9–11. We do not need to decide whether CyWee is correct, because we do not address LGE's enablement arguments in its Opposition to the Revised Motion to Amend. *See infra* part V.D.1.

[7] According to Professor LaViola's testimony, which we find persuasive, equation 5 represents a process model, and equation 1 represents the particular process model for the embodiment described in the '438 patent. *See* Ex. 1048, 103:20–21 ("The process model [in the '438 patent] is defined in equation 5, which in turn is equation 1."); *see also id.* at 108:4 ("the process model of equation 1"); *id.* at 134:21–24 ("[A]nyone of ordinary skill in the art would see that equation 1 is the equation that ultimately is being

matrix, a measurement model (equation 8)[8] and its corresponding covariance matrix, as well as Jacobians associated with each of the two models (equations 6, 7, and 10)[9] that linearize the nonlinear functions represented by each model. Ex. 1048, 102:15–103:7.

Next, "to provide a continuous loop," the method in step 740 outputs and substitutes the third quaternion (updated state) into the first quaternion (previous state) (step 710). *Id.* at 11:22–29. Ultimately, in step 745, the method uses the third quaternion to generate a "resulting deviation," in terms of yaw, pitch, and roll angles, with respect to the axes of the spatial pointer reference frame. *Id.* at 14:47–15:7. According to the '438 patent, one may use these resulting deviation angles to map locations from 3D space to corresponding locations that indicate where the device is pointing on a 2D display device. *See id.* at 15:39–17:40, Figs. 8, 9.

---

used in equation 5 . . . ."); *id.* at 135:20–22 (stating that the f function in equation 5 "relates to equation 1 as the underlying process model").

[8] Ex. 1048, 85:21–23 ("I believe equation 8 would be the [model] dealing with the measurement."); *id.* at 108:5–7 ("[T]he measurement model of H . . . would be defined by equation 8); *id.* at 141:15–16 ("The measurement model is really defined as equation 8.").

[9] Ex. 1048, 100:1–6 (identifying the Jacobian matrices as equations 6, 7, and 10).

C. CHALLENGED CLAIMS AND ASSERTED GROUNDS OF UNPATENTABILITY

ZTE challenges the patentability of claims 1, 4, 5, 14–17, and 19 of the '438 patent. Pet. 6, 31, 60. The table below is a summary of the grounds in the Petition:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
1, 4, 5, 14–17, 19	103(a)[10]	Yamashita,[11] Bachmann[12]
1, 4, 5, 14–17, 19	103(a)	Nasiri,[13] Song[14]

Independent claim 1, which is illustrative of the other claims, is as follows:

[1(pre)] 1. A three-dimensional (3D) pointing device subject to movements and rotations in dynamic environments, comprising:

[1(a)] a housing associated with said movements and rotations of the 3D pointing device in a spatial pointer reference frame;

[1(b)] a printed circuit board (PCB) enclosed by the housing;

---

[10] 35 U.S.C. 103(a) (2006), *amended by* Leahy–Smith America Invents Act, Pub. L. No. 112-29 § 103, sec. (n)(1), 125 Stat. 284, 287, 293 (2011) (effective Mar. 16, 2013). The filing date of the '934 application was November 11, 2010, which was before the effective date of this amendment. *See* Ex. 1001, code (22).

[11] Yamashita et al., US 8,267,785 B2 (issued Sept. 18, 2012) (Ex. 1006).

[12] Bachmann et al., US 7,089,148 B1 (issued Aug. 8, 2006) (Ex. 1007).

[13] Nasiri et al., US 8,462,109 B2 (issued June 11, 2013) (Ex. 1008). Nasiri incorporates, by reference, the entirety of Sachs et al., US 2009/0265671 A1 (published Oct. 22, 2009) (Ex. 1009) ("Sachs"). *See* Nasiri 1:47–19, 1:57–58, 13:65–14:3.

[14] Song et al., US 2007/0299626 A1 (published Dec. 27. 2007) (Ex. 1010).

[1(c)] a six-axis motion sensor module attached to the PCB, comprising

[1(d)] a rotation sensor for detecting and generating a first signal set comprising angular velocities ω_x, ω_y, ω_z associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame,

[1(e)] an accelerometer for detecting and generating a second signal set comprising axial accelerations Ax, Ay, Az associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame; and

[1(f)] a processing and transmitting module, comprising

[1(g)] a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting said first and second signal sets thereof and

[1(h)] a computing processor for receiving and calculating said first and second signal sets from the data transmitting unit,

[1(i)] communicating with the six-axis motion sensor module to calculate a resulting deviation comprising resultant angles in said spatial pointer reference frame

[1(j)] by utilizing a comparison to compare the first signal set with the second signal set whereby

[1(k)] said resultant angles in the spatial pointer reference frame of the resulting deviation of the six-axis motion sensor module of the 3D pointing device are obtained under said dynamic environments,

[1(l)] wherein the comparison utilized by the processing and transmitting module further comprises

[1(m)] an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set;

[1(n)] wherein the measured state includes a measurement of said second signal set and a predicted measurement obtained based on the first signal set without using any derivatives of the first signal set.

Ex. 1001 at 18:54–19:26 (ZTE's reference numbers and line formatting added). Claims 14 and 19 are also independent. *See id.* at 21:8–45, 22:17–54. Claims 4 and 5 depend from claim 1, while claims 15–17 depend from claim 14. *See id.* at 19:37–47, 22:5–8.

D. EXPERT TESTIMONY

1. Mr. Scott Andrews

ZTE supports its Petition with the Declaration of Scott Andrews, Oct. 31, 2018. Ex. 1003. Mr. Andrews has a Master of Science degree in Electronic Engineering from Stanford University, and is a consultant for Cogenia Partners, LLC, "focusing on systems engineering, business development and technical strategy supporting automotive and information technology." *Id.* ¶¶ 9, 15; *see also id.*, App'x A (Mr. Andrews's curriculum vitae). He also submitted a Rebuttal Declaration in Support of ZTE's Reply to CyWee's Patent Owner Response and its Opposition to CyWee's original Motion to Amend. Ex. 1030.

CyWee alleges that Mr. Andrews is not a person of ordinary skill in the art because in his deposition he "admits that he is not familiar with [extended Kalman filters] or the equations used with [extended Kalman filters]." PO Resp. 62 (citing Ex. 2016, 148:24–149:11, 150:3–13).

We note that in his deposition, Mr. Andrews did express familiarity with *linear* Kalman filters. *See* Ex. 2016, 148:24–149:6. His deposition came after he had submitted his initial Declaration (Ex. 1003), which did not

offer any expert opinion that relied on prior familiarity with extended Kalman filters. Subsequently, Mr. Andrews's Rebuttal Declaration (Ex. 1030) offered commentary on equations 1 and 5–10 of the '438 patent, as well as an application of an extended Kalman filter in Bachmann2[15] (Ex. 1032), which ZTE asserted in its Opposition to CyWee's original Motion to Amend.[16] *See, e.g.*, Ex. 1030 ¶¶ 33, 78–85, 147–148, 168–173. Mr. Andrews also stated that his Rebuttal Declaration is based on his "investigation and study of relevant materials," and his new testimony exhibits familiarity with extended Kalman filters. The evidence shows that after his deposition, Mr. Andrews familiarized himself with extended Kalman filters before testifying in his Rebuttal Declaration.

As we discuss below, we determine that a person of ordinary skill in the art would have had "knowledge of . . . Kalman filters and extended Kalman filters." *See infra* part IV.A. However, we do not place any restrictions on how the person obtains such knowledge. A person such as Mr. Andrews, who has extensive background and education in adjacent matters within the field, including knowledge of linear Kalman filters, may obtain the required knowledge through study, and Mr. Andrews evidently did so prior to his Rebuttal Declaration. Thus, Mr. Andrews' initial lack of

---

[15] João Luis Marins et al., *An Extended Kalman Filter for Quaternion-Based Orientation Estimation Using MARG Sensors*, Proc. 2001 IEEE/RSJ Int'l Conf. on Intelligent Robots & Systems (Oct. 29–Nov. 3, 2001) (Ex. 1032, "Bachmann2").

[16] LGE also asserts Bachmann2 in its Opposition to CyWee's Revised Motion to Amend. *See* Opp. RMTA 15–23. In support, Professor Michalson separately testifies about Bachmann2's use of an extended Kalman filter. *See* Ex. 1051 ¶ 69–70.

familiarity with extended Kalman filters is not an impediment to him having acquired knowledge sufficient to testify as a person of ordinary skill in the art for this proceeding.

Also, to be qualified as an expert, Mr. Andrews does not necessarily need to be a person of ordinary skill in the art as to the precise subject matter of the patent. A witness may qualify as an expert if they have "knowledge, skill, experience, training, or education" of a "scientific, technical, or other specialized" nature that is likely to help the Board "to understand the evidence or to determine a fact in issue." Fed. R. Evid. 702; *see also* PTAB Consolidated Trial Practice Guide, 34 (Nov. 2019), https://go.usa.gov/xpvPF ("CTPG") ("There is . . . no requirement of a perfect match between the expert's experience and the relevant field." (citing *SEB S.A. v. Montgomery Ward & Co.*, 594 F.3d 1360, 1373 (Fed. Cir. 2010))). We find that Mr. Andrews has such specialized knowledge, and that his expertise is helpful for us to understand the evidence and to determine the facts at issue, including the evidence and facts relating to extended Kalman filters. Therefore, we find that Mr. Andrews qualifies as an expert as to the entire subject matter of his declarations.

2. Professor Joseph LaViola

CyWee supports its arguments with the Declaration of Joseph LaViola, Ph.D., Feb. 20, 2018. Ex. 2001. Professor LaViola is the Charles N. Millican Professor of Computer Science in the University of Central Florida, and directs the Interactive Computing Experiences Research Cluster at that school. *See id.* ¶ 7; *see also* Ex. 2002, 1 (Professor LaViola's curriculum vitae). Professor LaViola also submitted a Declaration in Support of the Patent Owner Response and the Motion to Amend. Ex. 2015. He later

submitted a Third Declaration in Support of the Patent Owner Response and the Revised Motion to Amend. Ex. 2021.

ZTE and LGE do not contest that Professor LaViola is qualified as an expert witness as to the subject matter of his declarations, and we find that he is qualified.

3. Professor William Michalson

LGE supports its Opposition to CyWee's Revised Motion to Amend with the Declaration of Professor William Michalson. Ex. 1051. He is a Professor of Electrical and Computer Engineering at Worcester Polytechnic Institute, and holds collaborative appointments as a Professor of Computer Science, a professor of Mechanical Engineering, and a Professor of Robotics Engineering. Ex. 1052, 1 (Professor Michalson's curriculum vitae).

CyWee does not contest that Professor Michalson is qualified as an expert witness on the subject matter of his Declaration. But CyWee contends that we should disregard his Declaration based on passages that, according to CyWee, show that his Declaration is "obviously parroted attorney argument" that "should be given no weight." PO Reply RMTA 1–2.

First, CyWee argues that in one instance, Professor Michalson refers to himself in the third person. PO Reply RMTA 1 (citing Ex. 1051 ¶ 61 n.8); Tr. 75:2–8 (LGE asserting that Professor Michalson's reference to himself in the third person was a "singular occurrence"). The testimony in this passage relates to how a person of ordinary skill in the art would have understood the phrase "non-magnetic materials" in Bachmann, and states that Professor Michalson has reviewed, and agrees with, testimony on this subject in the prior IPR2018-01258 case by Google's expert Professor Sarrafzadeh. *See* Ex. 1051 ¶ 61 n.8 (citing Ex. 1058 ¶¶ 4–12).

As we discuss below, we find Professor Michalson's testimony on this point to be persuasive. *See infra* part IV.C.4. That Professor Michalson appears to refer to himself in the third person is probably an artifact of the drafting process. He executed his declaration under penalty of perjury, and we have no reason to question that the declaration ultimately reflects his actual opinion at the time he signed it. *See* Ex. 1051, 51.

Second, CyWee contends that Professor Michalson "makes assertions regarding procedure that are neither relevant to his purported analysis nor within his purported expertise." PO Reply RMTA 1 (citing Ex. 1058, ¶ 24 n.1, ¶ 38). In the cited passages, Professor Michalson expresses his "understanding" that CyWee has failed to meet its procedural obligation to provide sufficient support for the proposed substitute claims as a whole. Ex. 1058, ¶ 24 n.1, ¶ 38.

We do not interpret Professor Michalson's testimony as an expert opinion on the procedural requirements of a motion to amend. In any event, as we discuss below, we do not need to address the question of whether CyWee has failed to provide support for the proposed substitute claims as a whole. *See infra* parts V.B.1, V.C.2. Thus, even if these statements were offered as expert testimony, we would not rely on them in our decision.

Third, CyWee contends that Professor Michalson "cites to statutory provisions that are not at issue with no corresponding demonstration that Dr. Michalson even knows what those provisions are or mean," and in particular, "claims that the art cited by ZTE, not LG[E], is '102(b) art' when 102(b) is not asserted." PO Reply RMTA 1 (citing Ex. 1051 ¶ 56).

In the passage that CyWee cites, Professor Michalson states that "Yamamoto, Bachmann, and Bachmann2 published more than a year before

[November 11, 2010], so each qualifies as 102(b) art. Withanawasam[17] qualifies as 102(e) art, because its June 3, 2009 filing date is before the November 11, 2010 priority date." Ex. 1051 ¶ 56.[18] By this testimony, we do not understand Professor Michalson to be offering an expert opinion on the meaning of 35 U.S.C. § 102. Moreover, we discern no inconsistency in identifying § 102(b) as the statutory basis for qualifying a reference as prior art even when no patentability challenge is raised under § 102(b). In any event, we do not rely on this testimony to conclude that Withanawasam, Bachmann, and Bachmann2 qualify as prior art. *See infra* parts IV.C.2, V.D.2(a), V.D.3(a).[19]

Finally, CyWee argues that we should disregard Professor Michalson's Declaration because it "fails to identify the Board's Preliminary Guidance as something he reviewed." PO Reply RMTA 1 (citing Ex. 1051, iii–v, ¶ 10).

We do not understand Professor Michalson to be offering an expert opinion as to the content or meaning of the Preliminary Guidance, nor have we relied on his Declaration for that purpose.

---

[17] Withanawasam, US 2010/0312468 A1 (published Dec. 9, 2020) (Ex. 1049).

[18] Contrary to CyWee's argument, LGE does cite Yamamoto, Bachmann, Bachmann2, and Withanawasam in its Opposition to the Revised Motion to Amend. *See* Opp. RMTA 15–24.

[19] Because we find that LGE has not shown unpatentability under its alternative ground involving the combination of Yamamoto, Bachmann, and Bachmann2, we do not need to determine whether Yamamoto qualifies as prior art. *See infra* part V.D.3.

Having considered CyWee's arguments, we find that Professor Michalson is qualified as an expert witness as to the subject matter of his Declaration, and we have assigned weight to his testimony, as appropriate, as we discuss in the remainder of this decision.

III. TIME-BAR ISSUE

Before addressing the grounds of the Petition, we address CyWee's contention that we should not have instituted the *inter partes* review because ZTE is time barred. *See* PO Resp. 62–63.

Under 35 U.S.C. § 315(b), we may not institute an *inter partes* review "if the petition requesting the proceeding [wa]s filed more than 1 year after the date on which the petitioner, real party in interest, or privy of the petitioner [wa]s served with a complaint alleging infringement of the patent." CyWee contends that ZTE's Petition is time barred because it failed to identify time-barred real parties in interest or privies to this proceeding including LG Electronics Inc., Samsung Electronics Co. Ltd., and Huawei Device USA, Inc. PO Resp. 62–63. In support of this argument, CyWee points to "the facts and evidence (Exs. 2008–2014) already put forth in [a Motion for Additional Discovery and an associated Reply]." *Id.* at 62.[20]

CyWee's argument is similar to an argument that the Board rejected in the related *Google v. CyWee* case, where CyWee alleged that petitioner Google was time-barred. *See* IPR2018-01258, Paper 86, at 86–115. Unlike in *Google v. CyWee*, where CyWee filed a separate motion to terminate the

[20] On August 13, 2019, we granted in part CyWee's motion for additional discovery relating to the real-party-in-interest issue. *See* Paper 20.

proceeding, in this proceeding CyWee only addresses the issue in one paragraph of its Patent Owner Response. *See* PO Resp. 62–63. CyWee does not explain, with any specificity, why Exhibits 2008–2014 show that LGE, Samsung, Huawei, or any other entity is a real party in interest or privy to this *inter partes* review. To the extent that CyWee is relying on the same arguments it presented in *Google v. CyWee*, we adopt the reasoning of the Board in that case. The Board determined, among other things, that LGE, Samsung, and ZTE were not real parties in interest or privies because of their dealings with Google in relation to the Android operating system, or through their joint activities as defendants in prior litigation. *See* IPR2018-01258, Paper 86, 99–115. Therefore, we do not find CyWee's arguments persuasive and do not terminate the proceeding on the basis of a time bar.

IV. GROUNDS OF THE PETITION

For the reasons below, we determine that ZTE has shown, by a preponderance of the evidence, that claims 1, 4, 5, 14–17, and 19 are unpatentable under § 103. Before analyzing the Petition's two asserted grounds in detail, we address two matters that will underlie our analysis: the level of ordinary skill in the art, and the claim construction we will apply to the claim terms.

A. LEVEL OF ORDINARY SKILL IN THE ART

The level of ordinary skill in the pertinent art is one of the factual considerations relevant to patentability under § 103. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966). It is also relevant to how we construe the patent claims. *See Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed.

Cir. 2005) (en banc). To assess the level of ordinary skill in the art, we construct a hypothetical "person of ordinary skill in the art," from whose vantage point we assess obviousness and claim interpretation. *See In re Rouffet*, 149 F.3d 1350, 1357 (Fed. Cir. 1998). This legal construct "presumes that all prior art references in the field of the invention are available to this hypothetical skilled artisan." *Id.* (citing *In re Carlson*, 983 F.2d 1032, 1038 (Fed. Cir. 1993)).

ZTE's expert Scott Andrews opines that a person of ordinary skill in the art

> would have been familiar with motion sensors (such as gyroscopes, accelerometers, and magnetometers) and mobile device technology. Such [person] would have, at minimum, a bachelor's degree in computer science, computer engineering, electrical engineering, or a related field, with at least two years of experiences in research, design, or development of pointing devices that utilize[] motion sensors. Extensive experience and technical training may substitute for educational requirements, while advanced education such as a relevant MS or PhD might substitute for experience.

Ex. 1003 ¶ 22; *see also* Ex. 1030 ¶ 32 (same articulation in Mr. Andrews's Rebuttal Declaration). Although CyWee does not contest this articulation of the level of ordinary skill in its Patent Owner Response, CyWee's expert, Professor LaViola, opines that an ordinarily-skilled artisan would have had

> at least a Bachelor's Degree in Computer Science, Electrical Engineering, Mechanical Engineering, or Physics, or equivalent work experience, along with knowledge of sensors (such as accelerometers, gyroscopes, and magnetometers), and mobile computing technologies. In addition, a [person of ordinary skill in the art] would be familiar with Kalman filters and EKFs, and with equations typically used with such filters.

Ex. 2001 ¶ 27.

Thus, Mr. Andrews and Professor LaViola agree that a person of ordinary skill in the art could have had a bachelor's degree in computer science or electrical engineering, while Professor LaViola includes a degree in mechanical engineering or physics. Although Professor LaViola does not specify a particular number of years of work experience, both experts agree that the level of ordinary skill included knowledge of sensors (such as accelerometers, gyroscopes, and magnetometers) and mobile computing technologies. Unlike Mr. Andrews, Professor LaViola opines that a person of ordinary skill would have had familiarity with Kalman filters, extended Kalman filters and equations typically used with such filters.

The 3D pointing device of the '438 patent can be a mobile device and has a computing processor. *See* Ex. 1001, Figs. 3–4. Thus, we agree with both experts that a person of ordinary skill in the art would have had knowledge of mobile computing technologies. The patent also assumes some familiarity with sensors, so we agree with both experts that an ordinarily skilled artisan would have had knowledge of sensor systems.

We find persuasive Mr. Andrews's testimony that the '438 patent makes no explicit reference to a Kalman filter or an extended Kalman filter, and that "those equations disclosed are generic mathematical equations that might be associated with some elements of an [extended Kalman filter], but are not limited to [extended Kalman filters] only." Ex. 1030 ¶ 33. However, we also find persuasive Professor LaViola's testimony that equations 5–10 of the '438 patent reflect the general framework for an extended Kalman filter. *See supra* part II.B. Also, some of the prior art, including Bachmann and Bachmann2 (asserted in opposition to CyWee's Revised Motion to Amend), appears to presume at least some familiarity with Kalman or

extended Kalman filters. Ex. 1007, 9:37–40; Ex. 1032, 2005, 2008; *see also Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (the prior art itself may reflect the level of ordinary skill). Thus, we agree with CyWee that the level of ordinary skill would have included knowledge of Kalman filters and extended Kalman filters.

In *Google v. CyWee*, the Board also found—and Professor LaViola agreed with the petitioner in that case—that the level of ordinary skill in the field of the '438 patent included a knowledge of quaternion mathematics. *See* IPR2018-01258, Paper 86, at 15–16 (citing IPR2018-01258, Paper 28, at 29 (petitioner's reply); IPR2018-01258, Exhibit 1019, 33 (Professor LaViola's deposition testimony)). Although Professor LaViola does not mention quaternion mathematics in his articulation of the level of ordinary skill in the art for this case, he does not provide any reasons why his testimony in *Google v. CyWee* was in error. Mr. Andrews submitted his Declaration (dated October 31, 2018) before the Board's final written decision in *Google v. CyWee* (dated January 9, 2020), and his Declaration does not address this issue.

We agree with the Board's prior finding that the level of ordinary skill in the art includes knowledge of quaternion mathematics. First, we find Professor LaViola's testimony in the prior case to be credible. *See* IPR2018-01258, Exhibit 1019, 33. Second, the '438 patent assumes an understanding of quaternions and does not appear to define them for the reader. *See, e.g.*, Ex. 1001, 11:2. Third, the Bachmann reference, which we discuss in more detail below, states that "the field of quaternion mathematics is known to those having ordinary skill in the art and is explained in detail in numerous mathematical texts." Ex. 1007, 7:25–28. Bachmann describes the relevant

technical field as "methods and apparatus for tracking the orientation . . . of an object." *Id.* at 1:18–20. Such tracking is also one of the concerns of the '438 patent.[21] Thus, the use of quaternions for tracking objects appears to be a solution to a problem that a person of ordinary skill in the art would have encountered. *See In re GPAC, Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995) (stating that the "type of problems encountered in the art" is a factor in determining the level of ordinary skill in the art).

For the above reasons, we adopt the Board's articulation of the level of ordinary skill in the art in *Google v. CyWee*, with one slight modification to include knowledge of extended Kalman filters: a person of ordinary skill in the art would have had "an undergraduate degree in computer science, electrical engineering, mechanical engineering, or other related technical field, and knowledge of sensor systems, mobile computing technologies, Kalman filters, extended Kalman filters, and quaternion mathematics." IPR2018-01258, Paper 86, 16.

We regard this formulation to be essentially the same as that proposed by Professor LaViola, except for the addition of quaternion mathematics. Despite the difference, our decision would be the same had we adopted Professor LaViola's formulation, because if the person of ordinary skill did not have prior knowledge of quaternion mathematics, Bachmann points the reader to mathematical texts about quaternion mathematics that would have allowed an ordinarily skilled artisan to understand Bachmann's teachings and apply them to the claimed inventions. *See* Ex. 1007, 7:25–28.

---

[21] As we discuss below, we find that Bachmann is analogous to the invention recited in the challenged claims. *See infra* part IV.C.3.

B. CLAIM CONSTRUCTION

In an *inter partes* review filed before November 13, 2018, like this one,[22] the Board interprets claims of an unexpired patent using the broadest reasonable construction in light of the specification of the patent in which the claims appear. *See* 37 C.F.R. § 42.100(b) (2018), *amended by* Changes to the Claim Construction Standard for Interpreting Claims in Trial Proceedings Before the Patent Trial and Appeal Board, 83 Fed. Reg. 51,340, 51,359 (Oct. 11, 2018); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016) (upholding the use of the broadest reasonable interpretation standard); Office Patent Trial Practice Guide, 77 Fed. Reg. 48,756, 48,766 (Aug. 14, 2012).

Under the broadest reasonable construction standard, each claim term is generally given its ordinary and customary meaning, as one of ordinary skill in the art would have understood that meaning at the time of the invention and in the context of the entire disclosure. *See In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007); *Trivascular, Inc. v. Samuels*, 812 F.3d 1056, 1062 (Fed. Cir. 2016). A term's ordinary and customary meaning "is its meaning to the ordinary artisan after reading the entire patent." *Phillips*, 415 F.3d at 1321. Nevertheless, "it is always necessary to review the specification to determine whether the inventor has used any terms in a manner inconsistent with their ordinary meaning," because "[t]he specification acts as a dictionary when it expressly defines terms used in the claims or when it defines terms by implication." *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996).

[22] The filing date of the Petition was October 31, 2018. *See* Paper 3, 1.

For evaluating the challenged claims, ZTE argues that "all terms in the challenged claims should be given their plain meaning to a [person of ordinary skill in the art] at the time the patent application was filed." Pet. 10–11. ZTE particularly addresses the alleged plain meaning of the terms "three-dimensional (3D) pointing device," "six-axis motion sensor module," "calculating," and phrases in claims 1, 14, and 19 that include the terms "comparison" or "comparing." Pet. 11–14. CyWee proposes a different construction for "three-dimensional (3D) pointing device." *See* PO Resp. 18. Below, we address the above terms, as well as an additional term "attached to the PCB."

1. "Three-dimensional (3D) Pointing Device"

ZTE contends that the preambles of claims 1, 14, and 19 are limiting, and that the preamble term "three-dimensional (3D) pointing device" should be given its "plain and ordinary meaning." Pet. 11 (citing Ex. 1003 ¶ 55–57); ZTE Reply 1–3 (disputing CyWee's proposed construction requiring the device to be "handheld"). ZTE does not explain what it believes the plain and ordinary meaning would be.

CyWee's expert Professor LaViola agrees with ZTE's argument that the term "three-dimensional (3D) pointing device" in the preambles of claims 1, 14, and 19 is limiting. *See* Ex. 2001 ¶ 47. However, CyWee contends that the term should be construed as "a handheld device that detects the motion and orientation of said device in three-dimensions and is capable of translating the detected motions to control an output on a display." PO Resp. 18 (citing Ex. 2001 ¶ 47–50). CyWee contends that this construction is consistent with prior constructions by the Eastern District of

Texas, the District of Delaware, and the Board. *Id.* (citing Ex. 2003, 8; Ex. 2004, 2; Ex. 2006, 6; IPR2018-01258, Paper 7, at 16).

As we discuss below, CyWee does not contest ZTE's assertion that Yamashita discloses the preamble of claims 1, 14, and 19, including the term "three-dimensional (3D) pointing device." *See infra* part IV.C.5(a); *see also infra* parts V.D.2(c)(1), (c)(5) (addressing LGE's corresponding contentions in the Revised Motion to Amend, which CyWee does not contest). Thus, we do not need to construe this term. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) ("[W]e need only construe terms 'that are in controversy, and only to the extent necessary to resolve the controversy.'") (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999))).

2. "Six-axis Motion Sensor Module"

ZTE contends that we should construe the term "six-axis motion sensor module" as "a sensor module that detects movement in terms of three angular velocities ω_x, ω_y, ω_z, and the three axial accelerations Ax, Ay, Az." Pet. 12 (citing Ex. 1003 ¶ 58–60; Ex. 1001, 8:10–12 ("The term 'six-axis' means the three angular velocities ω_x, ω_y, ω_z, and the three axial accelerations Ax, Ay, Az.")). CyWee does not specifically address ZTE's proposed construction. *See* PO Resp. 18.

Independent claims 1, 14, and 19 already explicitly require the motion sensor module to measure three angular velocities ω_x, ω_y, ω_z, and three axial accelerations Ax, Ay, Az. *See* Ex. 1001, 18:61–19:3, 21:19–26, 22:28–35. Because ZTE's proposed construction would add nothing of substance to

the existing claim language, we need not construe the term "six-axis motion sensor module." *See Nidec*, 868 F.3d at 1017.

3. "Calculating"

ZTE contends that the term "calculating" or "to calculate" in claim 1 (Ex. 1001, 19:8, 19:10) should be given its plain and ordinary meaning, which is to "determine the value of something . . . by a mathematical process." Pet. 12 (citing Ex. 1003 ¶ 61). CyWee contends that this term does not need to be construed. PO Resp. 19 (citing Ex. 2001 ¶ 54; Paper 7, 13).

The term appears in limitations 1(h) and 1(i), and CyWee does not contest ZTE's assertion that Yamashita discloses these limitations. *See infra* part IV.C.5(e); *see also* V.D.2(c)(3) (addressing LGE's contentions about corresponding limitations 20(e) and 20(f) in the Revised Motion to Amend, which CyWee does not contest). Thus, we do not need to construe this term. *See Nidec*, 868 F.3d at 1017.

4. "Comparison" and "Comparing"

The challenged claims recite several limitations that refer to a "comparison" or "comparing." Claim 1 recites "utilizing a comparison to compare the first signal set with the second signal set whereby said resultant angles . . . are obtained under said dynamic environments." Ex. 1001, 19:12–17. Also, "the comparison utilized by the processing and transmitting module further comprises an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set." *Id.* at 19:17–23. Claims 14 and 19 each recite "comparing the second quaternion . . . with the measured axial accelerations . . . and the predicted axial accelerations," and "comparing the

current state with the measured state." *Id.* at 21:33–37, 40–41, 22:42–46, 49–50.

In district court, ZTE has contended that the terms "comparison" and "comparing" are indefinite. Pet. 13 (citing Ex. 1004, 15–18). For the purpose of its Petition, ZTE assumes that a comparison of two quaternion values involves setting the real parts to zero, and that otherwise, the term should be given its plain and ordinary meaning, which includes "performing calculations based on first and second sensor signals to obtain the deviation angles of the device with respect to the spatial pointing frame." *Id.* (citing Ex. 1003 ¶ 62–65).

CyWee contends that following passage in the '438 patent is an explicit definition of the term "comparison":

> The term of "comparison" of the present invention may generally refer to the calculating and obtaining of the actual deviation angles of the 3D pointing device 110 with respect to the first reference frame or spatial pointing frame X_P Y_P Z_P utilizing signals generated by motion sensors while reducing or eliminating noises associated with said motion sensors.

Ex. 1001, 2:26–32; *see* PO Resp. 19. ZTE disagrees that this passage "rise[s] to the standard of lexicography that would allow for departure from the plain meaning," and argues that the passage is "inconsistent with the plain and ordinary meaning." Pet. 13.

Based on the evidence of record, the '438 patent clearly and unambiguously defines "comparison" as having at least the meaning in the above-quoted passage. Therefore, we construe the terms "comparison" and "comparing" as "the calculating and obtaining of the actual deviation angles of the 3D pointing device . . . with respect to the first reference frame or spatial pointing frame X_P Y_P Z_P utilizing signals generated by motion

sensors while reducing or eliminating noises associated with said motion sensors." *Id.* at 2:28–32.[23]

5. "Attached to the PCB"

Claim 1 recites "a six-axis motion sensor module *attached to the PCB*." Ex. 1001, 18:61 (emphasis added). CyWee argues that neither Yamashita nor Bachmann discloses this limitation. PO Resp. 27–29. While neither party asks us to construe the term "attached to the PCB,"[24] CyWee's arguments depend on the meaning of this term. *See infra* part IV.C.5(d).

The '438 patent has an express definition of the term "printed circuit board (PCB)," which includes multiple PCBs: "[I]t can be understood that a printed circuit board (PCB) recited herein may refer to more than one PCBs such that motion sensors such as rotation sensors or gyroscopes and/or accelerometers of the six-motion sensor module may be attached to more than one PCBs." *Id.* at 18:47–51. In light of this express definition, which is consistent with the remainder of the '438 patent specification and the evidence of record, we conclude that the broadest reasonable interpretation of "attached to the PCB" is "attached to one or more PCBs."

---

[23] In a parallel proceeding involving the '438 patent, the Eastern District of Texas likewise held that the quoted passage specifically defines the term "comparison." *See* Ex. 2004, 10. This is also the construction that the Board adopted in *Google v. CyWee*. *See* IPR2018-01258, Paper 86, 23.

[24] Although ZTE did not ask us to construe the term "attached to the PCB" in its Petition, Mr. Andrews opined in his Rebuttal Declaration that a person of ordinary skill in the art would have understood from the text of the '438 patent that the term can include attachment to more than one PCB. Ex. 1030 ¶ 69–72. We find this testimony persuasive.

C. GROUND BASED ON YAMASHITA AND BACHMANN

In the first ground of the Petition, ZTE argues that claims 1, 4, 5, 14–17, and 19 of the '438 patent would have been obvious over Yamashita in view of Bachmann. Pet. 6.

A claim is unpatentable under § 103(a) for obviousness if the differences between the claimed subject matter 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." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). A successful petition must "articulate specific reasoning, based on evidence of record, to support the legal conclusion of obviousness." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016) (citing *KSR*, 550 U.S. at 418); *see also* 35 U.S.C. § 322(a)(3); 37 C.F.R. §§ 42.22(a)(2), 42.104(b)(4) (2019). When a ground in a petition is based on a combination of references, we consider "whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue." *KSR*, 550 U.S. at 418 (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)).

We base our obviousness inquiry on factual considerations including (1) the scope and content of the prior art, (2) any differences between the claimed subject matter and the prior art, (3) the level of skill in the art, and (4) any objective indicia of obviousness or non-obviousness that may be in evidence. *See Graham*, 383 U.S. at 17–18. Considering these factors,[25] we

[25] The parties did not produce evidence about objective indicia of obviousness or non-obviousness, except to the extent this may include teaching away. *See* PO Resp. 24–25, 28; *Ecolochem, Inc. v. S. Cal. Edison*

determine that ZTE has shown, by a preponderance of the evidence, that claims 1, 4, 5, 14–17, and 19 would have been obvious over Yamashita in view of Bachmann.

After providing an overview of Yamashita and Bachmann, we address whether Bachmann is analogous art, ZTE's rationale for combining Yamashita with Bachmann, and the specific limitations of the challenged claims.

1. Overview of Yamashita

Yamashita is a U.S. Patent based on an application filed December 22, 2008, and issued September 18, 2012. Ex. 1006, codes (22), (45). Yamashita's filing date precedes November 11, 2010, the filing date of the '934 application which issued as the '438 patent. *See* Ex. 1001, codes (21), (22). Yamashita's filing date also precedes January 6, 2010, the filing date of the provisional '558 application to which the '438 patent claims priority. *See* Ex. 1001 1:13–15, code (60). CyWee does not present any evidence that any challenged claim antedates Yamashita's filing date. *See* PO Resp. 8–9. Thus, we conclude that Yamashita is prior art to all challenged claims under § 102(e).[26]

Co., 227 F.3d 1361, 1379 (Fed. Cir. 2000) (classifying teaching away as an objective consideration). We address CyWee's teaching-away arguments in the context of whether there was motivation to combine the references. *See infra* parts IV.C.4, IV.C.5(d), note 30.

[26] 35 U.S.C. § 102(e) (2006), *amended by* Leahy–Smith America Invents Act, Pub. L. No. 112-29 § 102, sec. 3(b)(1), 125 Stat. 284, 286 (2011) (effective Mar. 16, 2013).

According to Professor LaViola's undisputed testimony, Yamashita discloses technology associated with the Nintendo Wii Remote (a game controller), and its associated Wii MotionPlus module (an attachable gyrosensor unit). Ex. 2001, ¶ 61. Yamashita's Figure 3, reproduced below, illustrates both the controller and the attachable module:

FIG. 3

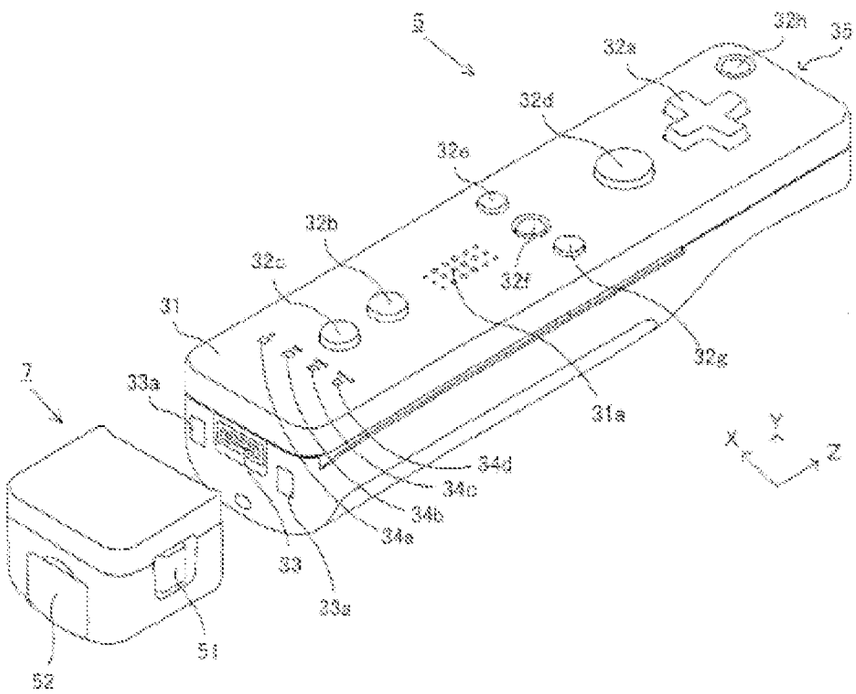


Figure 3 depicts game controller 5, and associated gyrosensor unit 7 in a non-attached configuration. Controller 5 includes housing 31 with various buttons 32a–32h for operating the device. Ex. 1006, 9:42–57. Gyrosensor unit 7 includes gyrosensors "for sensing an angular velocity around the three axes," and is detachably attached on connector 33 of controller 5. *Id.* at 11:14–17.

Figure 7, reproduced below, is a block diagram showing the interior parts of controller 5 and gyrosensor unit 7:

FIG. 7

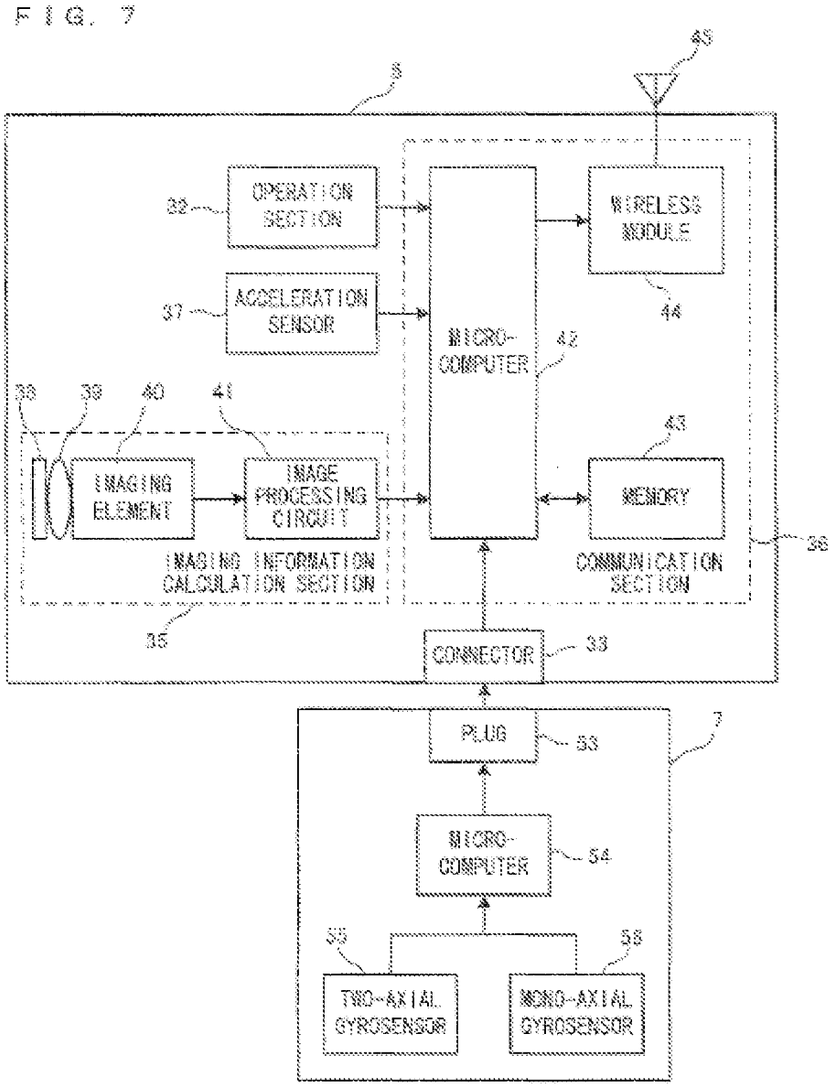
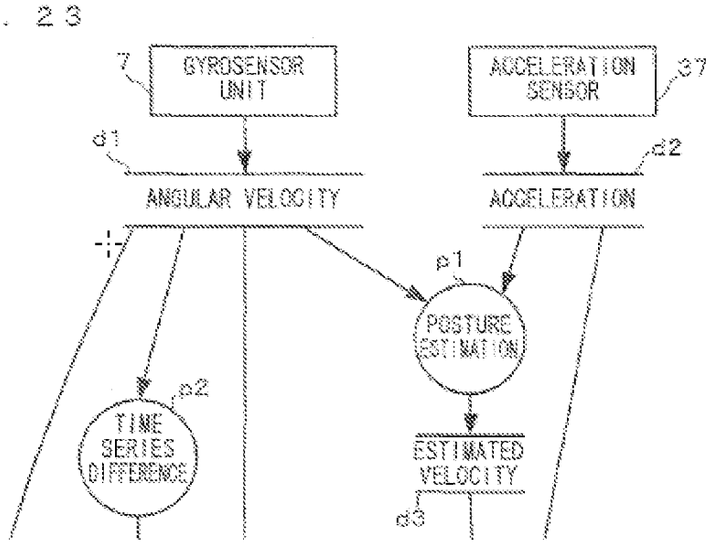


Figure 7 depicts game controller 5 and gyrosensor unit 7. On a substrate (not shown) within game controller 7, acceleration sensor 37 detects acceleration in three axes, and it outputs the acceleration data to communication section 36, which includes microcomputer 42. *Id.* at 10:38–43, 12:62–67, 13:11–13. Connector 33, also on substrate 30, detachably connects to plug 53 on

gyrosensor unit 7. *Id.* at 11:8–9, 16–20. Gyrosensor unit 7 also includes microcomputer 54, and gyrosensors 55 and 56, which sense angular velocity around three axes (X, Y, and Z) and the unit transmits that information to controller 5. *Id.* at 14:28–34.

Yamashita discloses that one may calculate the estimated posture (i.e., orientation) of controller 5 with reference to the measured acceleration and angular velocity. *Id.* at 19:29–40. Yamashita's Figure 23, a relevant portion of which we reproduce below, is an overview of processing steps for making this calculation:

FIG. 23



This reproduced portion of Figure 23 depicts angular velocity data d1 from gyrosensor unit 7 and acceleration data d2 from acceleration sensor 37, which are combined in posture estimation step p1 to produce estimated posture d3.[27] *Id.* at 19:1–8. According to Yamashita, "any method is usable"

[27] Although Figure 23 labels d3 as "estimated velocity," the associated text refers to d3 as an "estimated posture." Ex. 1006, 19:8, 41, 44.

for "calculating the estimated posture based on the acceleration and the angular velocity." *Id.* at 19:8–10.

2. Overview of Bachmann

Bachmann is a U.S. Patent that issued August 8, 2006. Ex. 1007, code (45). This predates, by more than a year, the earliest priority date asserted in the '438 patent, which is January 6, 2010. *See* Ex. 1001 1:13–15, code (60). Thus, we conclude that Bachmann is prior art to all challenged claims under 35 U.S.C. § 102(b) (2006).

Bachmann describes "a method of determining an orientation of a sensor," Ex. 1007, code (57), and particularly "for tracking the posture of articulated rigid bodies using quaternion based attitude estimation filtering and displaying the posture of the body." Ex. 1007, 1:19–20, 1:23–26. For example, "a plurality of sensors, each mounted to a limb of an articulated rigid body[,] can be used to track the orientation of each limb." *Id.* at 5:26–28.

Figure 4, reproduced below, shows an example of using the sensors to track human limbs:

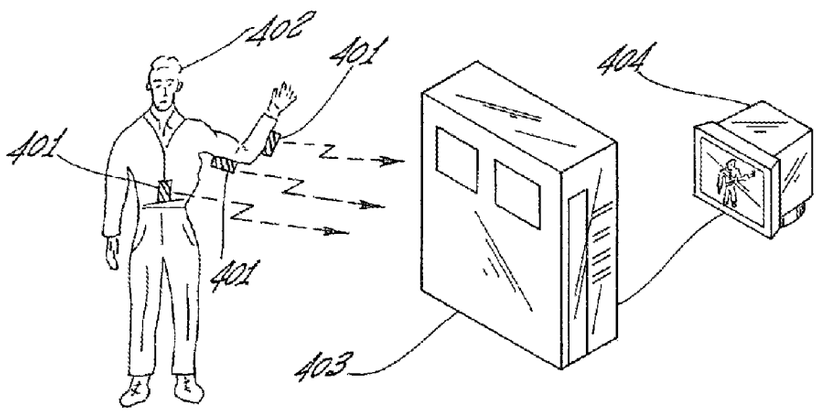


Fig 4

Figure 4, above, shows an embodiment "of an overall system implementation in accordance with the principles" described by Bachmann. Ex. 1007, 13:33–35. This overall system uses three sensors 401 to track the posture of human body 402. *Id.* at 13:35–36, 13:64–67. Sensors 401 send sensor information to processing unit 403, which calculates the posture of body 402 and outputs a display signal to display 404, "thereby enabling the movement of the articulated rigid body 402 to be incorporated into a synthetic or virtual environment and then displayed." *Id.* at 14:23–26.

In one embodiment, "the sensors include a three-axis magnetometer and a three-axis accelerometer." *Id.* at 7:34–35. In another embodiment, "the magnetometers and accelerometers are supplemented with angular rate detectors configured to detect the angular velocity of the sensor (comprising so-called Magnetic, Angular Rate, Gravity (MARG) sensors)." *Id.* at 7:35–40. Thus, "[e]ach MARG sensor contains angular rate detectors, accelerometers, and magnetometers." *Id.* at 7:40–41; *see also id.* at 14:37–59 (describing a commercially available MARG sensor).

In addition to tracking the posture of a human body as shown in Figure 4, Bachmann teaches that the disclosed sensors "can be used to track motion and orientation of [other] simple rigid bodies as long as they are made of non-magnetic materials. Examples include, but are not limited to hand-held devices, swords, pistols, or simulated weapons." Ex. 1007, 13:43–51; *see also id.* at 13:57–62 (suggesting use of the sensors to track "non-magnetic prosthetic devices, robot arms, or other machinery").

Bachmann uses an "attitude estimation filter," in conjunction with data supplied by the sensors, "to produce a sensor orientation estimate expressed in quaternion form." Ex. 1007, 7:18–19, 7:32–34. Figure 3 of Bachmann is a block diagram of this filter:

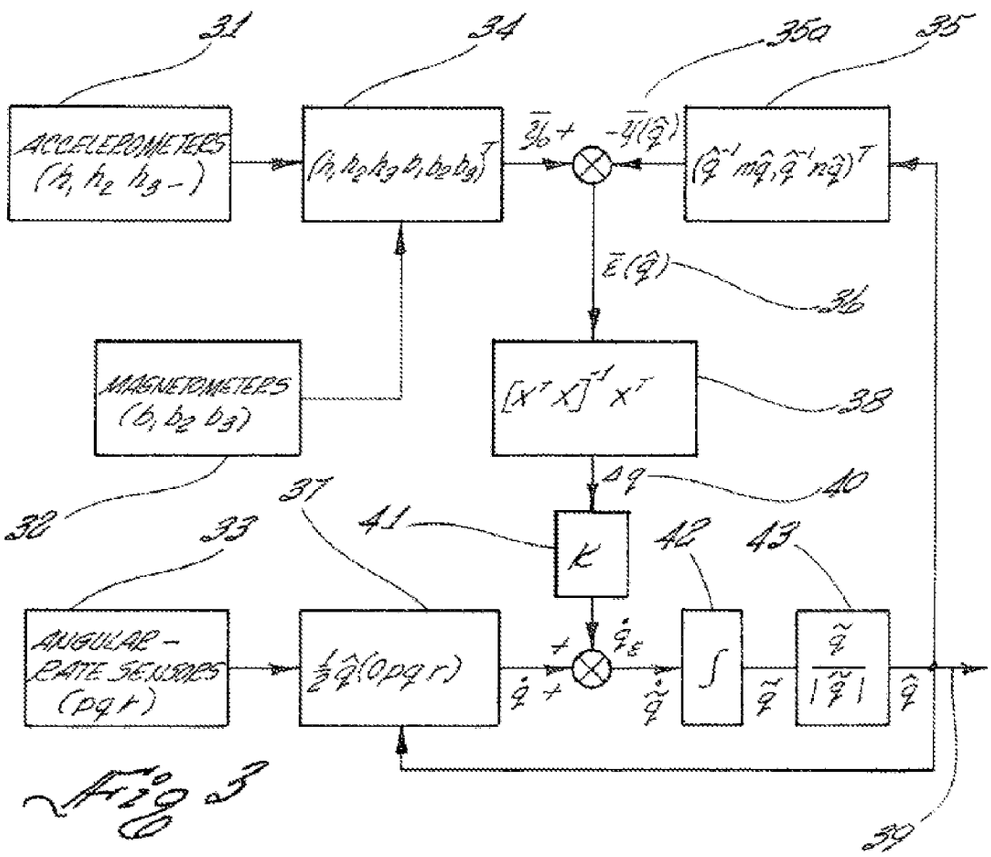


Fig. 3

In broad terms, the filter shown above in Figure 3 takes three-axis acceleration data (h_1, h_2, h_3) from accelerometer 31, three-axis magnetic field data (b_1, b_2, b_3) from magnetometer 32, and three-axis angular rate data (p, q, r) from angular rate sensor 33, and combines the nine axes of sensor data to output a quaternion representation $\hat{q}$ (39) of the orientation of the tracked object. Ex. 1007, 10:10–14.

The accelerator and magnetometer data (31 and 32) are considered to be "complementary" to angular rate data (p, q, r) (box 33). According to Bachmann, if angular rate data (p, q, r) were perfectly accurate, it could be used, directly, to calculate rate quaternion $\dot{q}$ (box 37) based on the sensor reference frame using quaternion $\hat{q}$ representing the current orientation. *See* Ex. 1007, 10:18–32. Rate quaternion $\dot{q}$ could then be converted, iteratively, to the new orientation quaternion $\hat{q}$ by integration 42 and normalization 43. *See id.* at 10:33–36.

However, to account for the fact that the angular rate sensors drift over time, $\dot{q}$ must be continuously corrected using the "complementary" accelerator and magnetometer data. Ex. 1007, 10:36–42. In other words, to correct three-axis angular rate sensor data (p, q, r) in box 33, Bachmann's system "uses measurements of local magnetic field 32 and local gravity 31 to correct the angular rate information $[\dot{q}]$." *Id.* at 9:55–58. The correction to measured rate quaternion $\dot{q}$ uses Gauss-Newton iteration 38. *Id.* at 10:42–45. The Gauss-Newton iteration yields correction factor $\dot{q}_\varepsilon$, which is added to rate quaternion $\dot{q}$ before integration. *See id.*, Fig. 3 (output $\dot{q}_\varepsilon$ to box 41, which is added to $\dot{q}$).

To obtain correction factor $\dot{q}_\varepsilon$, Bachmann's filter combines accelerometer 31 and magnetometer 32 measurements into a single vector

$\vec{y}_0$ (34). *See* Ex. 1007, 8:37–51. The filter then compares measurement vector $\vec{y}_0$ with calculated vector $\vec{y}(\hat{q})$ (box 35a), which is calculated by applying a physical model to updated orientation estimate $\hat{q}$. *See id.* at 8:52–9:8, 9:65–10:2. Measurement error $\vec{\varepsilon}(\hat{q})$ (box 36) is the difference between measurement vector $\vec{y}_0$ and calculated vector $\vec{y}(\hat{q})$. *Id.* at 9:13, 10:2–5.

In box 38, the filter uses Gauss-Newton iteration to minimize the square of error vector $\vec{\varepsilon}(\hat{q})$. *See id.* at 9:18–35, 10:2–9, 10:42–45. The Gauss-Newton iteration calculates Δq_{full} (40) using equation 12, also shown in box 38:

$$\Delta q_{full} = [X^T X]^{-1} X^T \vec{\varepsilon}(\hat{q})$$

where $\vec{\varepsilon}(\hat{q})$ is measurement error 36 and X is the following matrix:

$$X_{ij} = \left[\frac{\partial y_i}{\partial q_j}\right]$$

Ex. 1007, 10:46–65. Because the value of Δq_{full} is corrupted by noise, the filter accounts for the noise by using a scalar multiple (filter gain k in box 41). *Id.* at 10:66–11:12. The result of the Gauss-Newton iteration is the following equation 16, for each time step:

$$\hat{q}_{n+1} = \hat{q}_n + \frac{1}{2}\hat{q}^B \omega \Delta t + \alpha [X^T X]^{-1} X^T \varepsilon(\hat{q}_n)$$
$$\hat{q}_n + k\Delta t \Delta q_{full} + \dot{q}_{measured}\Delta \mathrm{t}$$

Id. at 11:15–20. According to uncontested testimony by Mr. Andrews, the term $\frac{1}{2}\hat{q}^B \omega \Delta t$ "represents the measured angular rate converted from the sensor reference frame to the earth reference frame." Ex. 1003 ¶ 162. Equation 16 shows how to calculate the next estimate of sensor orientation $\hat{q}_{n+1}$ (at time $n + 1$) based on the various inputs. *See id.* at 11:12–14.

3. Whether Bachmann is Analogous Art

"To be considered within the prior art for purposes of the obviousness analysis, a reference must be analogous." *Circuit Check Inc. v. QXQ Inc.*, 795 F.3d 1331, 1335 (Fed. Cir. 2015) (citing *Wang Labs., Inc. v. Toshiba Corp.*, 993 F.2d 858, 864 (Fed. Cir. 1993)). We therefore address CyWee's contention that Bachmann is not analogous to the claimed invention. *See* PO Resp. 19–23.

Two separate tests define the scope of analogous prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed; and (2) if the reference is not within the field of the inventor's endeavor, whether the reference is still "reasonably pertinent to the particular problem with which the inventor is involved." *In re Bigio*, 381 F.3d 1320 (Fed. Cir. 2004). CyWee contends that Bachmann does not satisfy either test. *See* PO Resp. 19–23.

Regarding the first test, ZTE argues that Bachmann is in the same field as the '438 patent. *See* Pet. 25. Although ZTE did not explain the scope of that field in the Petition, ZTE argues in its Reply that the field of endeavor "relates to the calculation of orientation from motion sensors generally." ZTE Reply 6.

In contrast, CyWee argues that "[t]he field of endeavor of the '438 Patent is handheld '3D Pointing Devices,' or, alternatively and more broadly, handheld 'pointing devices and their applications.'" PO Resp. 21 (citing Ex. 2001 ¶ 87); *id.* at 19 (citing Ex. 2001 ¶ 83). CyWee's articulation depends on its proposed construction of the term "3D pointing device," which according to CyWee means "a handheld device that detects the motion and orientation of said device in three-dimensions and is capable of translating the detected

motions to control an output on a display." PO Resp. 18 (citing Ex. 2001 ¶ 47–50); *see also id.* at 20 (acknowledging that CyWee's articulation of the field of endeavor depends on its proposed construction of "3D pointing device"); *supra* part IV.B.1. According to CyWee, since Bachmann does not relate to a "3D pointing device" as CyWee construes that term, it cannot be in the same field of endeavor as the '438 patent. PO Resp. 22 (citing Ex. 2001 ¶ 88).

As we discuss above, we do not need to construe the term "3D pointing device" for this decision, because CyWee does not contest that Yamashita discloses a 3D pointing device. *See supra* part IV.B.1. But we find CyWee's argument persuasive that the field of invention of the '438 patent involves 3D pointing devices, given that the '438 patent specification characterizes the field as such, and all the claimed inventions concern 3D pointing devices. *See* Ex. 1001, 1:15–26 (characterizing the field of invention as relating to a 3D pointing device), 18:54–22:54 (claims 1–19).

Although Bachmann teaches that the disclosed sensors can be used to track simple rigid bodies including "hand-held devices," *see* Ex. 1007, 13:43–51, and that movements of these bodies can "be incorporated into a synthetic or virtual environment and then displayed," *id.* at 14:23–26, ZTE has not persuasively shown that Bachmann involves a 3D pointing device in the sense that this term is used in the '438 patent. Thus, we find that ZTE has not shown, by a preponderance of the evidence, that Bachmann is in the same field of endeavor as the '438 patent.

Next, we turn to the second test for analogous art: whether Bachmann is reasonably pertinent to the challenged claims. This requires us to evaluate whether Bachmann "logically would have commended itself to an inventor's

attention in considering [the] problem." *In re Icon Health and Fitness, Inc.*, 496 F.3d 1374, 1379–80 (Fed. Cir. 2007) (quoting *In re Clay*, 966 F.2d 656, 658 (Fed. Cir. 1992)). "If a reference disclosure has the same purpose as the claimed invention, the reference relates to the same problem, and that fact supports use of that reference in an obviousness rejection." *Clay*, 966 F.2d at 659.

ZTE alleges that Bachmann addresses "the problems of improving the accuracy of the orientation calculation," as shown in more detail in ZTE's claim charts. Pet. 25 (citing Ex. 1003 ¶ 91); *see also* ZTE Reply 10; Ex. 1030 ¶¶ 53–54 (additional testimony by Mr. Andrews). CyWee frames the problem more narrowly: "The '438 Patent is involved with the problem of compensating accumulated errors of signals of a 3D Pointing Device using a six-axis sensor module for the purposes of being able to better map the dynamic movements of that Pointing Device onto a display and more precisely control that display." PO Resp. 22 (citing Ex. 2001 ¶ 89); *accord id.* at 20.

For the reasons below, we find ZTE's argument persuasive, and agree that Bachmann would have logically commended itself to an inventor's attention when considering the problem as ZTE frames it.

In describing the problem to be addressed by the '438 patent, the "Description of the Related Art" section in the '438 patent emphasizes perceived deficiencies with the prior art. These include the need for "an improved pointing device *with enhanced calculating or comparison method* capable of accurately obtaining and calculating actual deviation angles in the spatial pointer frame." Ex. 1001, 3:52–57 (emphasis added). The '438 patent also highlights "a need to provide *an enhanced comparison method*

applicable to the processing of signals of motion sensors such that errors and/or noises associated with such signals or fusion of signals from the motion[] sensors may be corrected or eliminated." *Id.* at 3:62–66 (emphasis added).

CyWee's expert Professor LaViola confirms that one focus of the claimed invention is to "appl[y] a novel enhanced comparison method to reduce and remove errors and noise in the sensor readings that normally accumulate over time in order to better map the movements of the device and have the capability to more precisely control a display." Ex. 2001 ¶ 31 (citing Ex. 1001, 4:20–43); *see also id.* ¶ 35 ("The '438 Patent further discloses and claims an enhanced method for comparing the various signal sets that is capable of eliminating the errors and noise that accumulate over time." (citing Ex. 1001, 4:20–30))); *id.* ¶ 38 (stating that, because miniature accelerometers that existed prior to the '438 patent could not distinguish between different types of acceleration, "an enhanced filter method is necessary to remove extraneous readings of other types of acceleration as high-frequency noise to produce a more accurate reading.").

We agree with CyWee that, in relation to the claimed invention, there are other aspects of concern beyond the need for improved error compensation, such as using the enhanced error compensation to capture full 3D information and outputting the pointing device's movement pattern on a display frame. *See* Ex. 1001, 2:47–55 (noting that a prior art pointing device with a five-axis motion sensor did not output deviation angles in a 3D reference frame), 3:66–4:2 (recognizing a need to map 3D deviations to a 2D reference frame). But these are complementary aspects of the overall problem faced by an inventor, and do not diminish the fact that improving

error compensation with an enhanced comparison method is a central problem of the claimed invention.

Furthermore, while the '438 patent describes mapping movements of the pointing device to a 2D display in order to control the display, none of the challenged claims include such mapping as a limitation. *See, e.g.*, Ex. 1001, 18:54–26 (claim 1, referring to a "spatial pointer reference frame," but not including any step of mapping movements or rotations from that frame onto a display reference frame); *but see id.* at 22:9–16 (claim 18, not challenged in the Petition, which includes such a "mapping step"). Thus, for these claimed inventions, the mapping step was not directly an issue of concern.

Based on this understanding of the problem confronting an inventor with respect to the challenged claims, we find that Bachmann logically would have commended itself to an inventor's attention. The filtering method illustrated in Bachmann's Figure 3, reproduced above, illustrates the collection of data from the same kinds of sensors used in the '438 patent. *See* Ex. 1007, Fig. 3 (boxes 31 and 33). And Bachmann repeatedly comments on the ability of its method to correct for the same kinds of errors that are of concern in the '438 patent. *See id.* at 7:10–12 ("[A]ngular velocity information can be used to correct for time lag errors."), 7:42–45 ("Unlike[] other sensors known in the art, sensor embodiments of the invention can correct for drift continuously without any requirement for still periods."), 8:29–31 ("Determination of this local gravity vector allows the local vertical to be determined allowing correction of orientation relative to a vertical axis."), 8:33–34 ("This information can be used to correct rate sensor drift errors in the horizontal plane."), 9:54–58 ("[S]uch a filtering embodiment

measures angular rate information 33, and uses measurements of . . . local gravity 31 to correct the angular rate information or integrated angular rate information.").

In finding that Bachmann is an analogous reference, we have also considered three rebuttal arguments by CyWee, which we find unpersuasive. First, CyWee argues that Bachmann "expressly teaches away from using its sensor system and sensor fusion method with devices made of magnetic materials . . . such as smartphones or game controllers that could be used as 3D Pointing Devices." PO Resp. 22–23 (citing Ex. 1007, 13:42–47; Ex. 2015 ¶ 9). As we discuss below, we disagree that Bachmann teaches away from the claimed invention. *See infra* part IV.C.4.

Second, CyWee argues that "while Bachmann references handheld devices, it expressly teaches that its invention is meant for use with articulated rigid objects." *Id.* at 23 (citing Ex. 1007, 13:49:51). While Bachmann teaches using its filter for tracking articulated rigid objects, CyWee does not point to any evidence that a person of ordinary skill in the art would have been dissuaded from using the filter in other ways, such as in a 3D pointing device.

Finally, CyWee argues that a search on Google Patents using the words "pointing device" yielded about 199,000 patents and publications, but none of them cited Bachmann. PO Resp. 23 (citing urls linking to search results). According to CyWee, this supports Professor LaViola's opinion that Bachmann would not have logically commended itself to the problem of "using a handheld 3D pointing device to control a display and compensating for accumulated sensor errors of such a device." *Id.* (citing Ex. 2001 ¶¶ 83–90).

We find CyWee's search results unpersuasive, given that an inventor's area of concern involves the problem of compensating for accumulated sensor errors, and not merely the design or use of a pointing device. We also afford this argument less weight than other evidence of record, such as Professor LaViola's testimony that Bachmann's work, including his patent, came up when he was doing predictive motion tracking research around the year 2001. Ex. 1020, 77:3–23; *see also* ZTE Reply 10–11 (arguing that in *Google v. CyWee*, Google contended that it had performed a different search that returned contrasting results to that of CyWee (citing Ex. 1029, 10)).

In light of the arguments and evidence discussed above, we find that Bachmann logically would have commended itself to an inventor's attention in considering the problem of compensating accumulated measurement errors in a six-axis motion sensor. Thus, Bachmann is analogous to the claimed invention of the '438 patent.

4. Combination of Yamashita and Bachmann; Teaching-Away

ZTE contends that a person of ordinary skill in the art at the time of the claimed invention would have had reason "to use Yamashita's game console device with Bachmann's sensors and filter calculations." Pet. 22. In particular, ZTE notes that Yamashita teaches "that a key reason for using the combined acceleration and angular velocity sensors is to compensate for errors," but acknowledges "that the described solution still exhibits errors when the device is moving. *Id.* (citing Ex. 1006, 1:29–40, 1:49–60; Ex. 1003 ¶¶ 84–85). According to ZTE, a person of ordinary skill in the art "would have understood that [using] additional sensors, and additional types of

sensors" beyond those that Yamashita describes, "would have yielded at least better error and noise control." *Id.* (citing Ex. 1003 ¶ 83).

Thus, ZTE argues that a person of ordinary skill in the art would have had reason to use Bachmann's filter and commercially available nine-axis MARG sensor module to further reduce the errors in Yamashita's pointing device. Pet. 22–23 (citing Ex. 1007, 14:37–57; Ex. 1003 ¶¶ 86–87); *see also* Pet. 24 (citing Ex. 1003 ¶ 89). ZTE contends that an ordinarily skilled artisan "would have been able to integrate these sensors into Yamashita's device using standard conditioning circuits, samplers and analog-to-digital converters, making adjustments as necessary." Pet. 24 (citing Ex. 1003 ¶ 89).

ZTE also argues that an ordinarily skilled artisan would have used Bachmann's filter with the combination because "those filter techniques were adapted directly to MARG sensors," and Bachmann teaches that "quaternion-based [filter] techniques are computationally more efficient" than non-quaternion-based techniques because they "avoid singularities that might otherwise occur at certain sensor orientations." Pet. 23 (citing Ex. 1007, 5:33–7:45; Ex. 1003 ¶ 88).

According to ZTE, a person of ordinary skill in the art would have expected success in combining Yamashita with Bachmann because "[i]n the timeframe, microcomputers and microcontrollers with sufficient power to implement Bachmann's filter were readily available," and the calculations for transforming Bachmann's orientation output into Euler angles was "well-known and that was the conventional form of such output." Pet. 24 (citing Ex. 1003 ¶ 90).

In response, CyWee argues that a person of ordinary skill in the art "would not have been motivated to combine *Yamashita* and *Bachmann*," in

part because Bachmann "merely contemplates mounting its sensor systems on props for motion tracking; it does not teach incorporating its sensor systems into other electronic devices." PO Resp. 24 (citing Ex. 1007, 13:42–51, Ex. 2001 ¶ 58; Ex. 2015 ¶ 9). Although CyWee acknowledges that Bachmann refers to "handheld" devices, CyWee contends that "it expressly teaches that its invention is meant for use with articulated rigid objects." PO Resp. 24 (citing Ex. 1007, 13:49–51).

We do not find CyWee's argument persuasive. Although Bachmann specifically teaches using the filter in combination with sensors attached to articulated rigid objects, CyWee does not adequately explain why this teaching would have dissuaded an ordinarily skilled artisan from combining the filter with a 3D pointing device. *See Syntex (U.S.A.) LLC v. Apotex, Inc.*, 407 F.3d 1371, 1380 (Fed. Cir. 2005) ("[A] prior art reference that does not specifically refer to one element of a combination does not, per se, teach away. If it did, only references that anticipate could be used to support an obviousness analysis.").

Next, CyWee contends that Bachmann "expressly teaches away from using its sensor system and fusion method on any rigid bodies made of magnetic materials." PO Resp. 24 (citing Ex. 1007, 13:42–47; Ex. 2015 ¶ 9).

As background, we note that Bachmann's sensors contain a three-axis magnetometer, and the filter "uses measurements of local magnetic field 32 . . . to correct the angular rate information or integrated angular rate information." Ex. 1007, 9:55–58. However, Bachmann notes that the magnetometer measurements are not "perfect measurements of . . . the local magnetic field," and are "frequently corrupted by noise." *Id.* at 10:66–11:1. Bachmann uses a correction factor to account for this noise, *id.* at 11:1–12,

and teaches that the MARG sensor should be calibrated to account for variations in the direction of the local magnetic field, *id.* at 14:60–67. Thus, Bachmann expresses a general concern for the accuracy of the magnetometer measurements, and states that the disclosed sensors "can be used to track motion and orientation of simple rigid bodies as long as they are made of non-magnetic materials." Ex. 1007, 13:43–47.

CyWee, relying on Professor LaViola's testimony, argues that "[g]aming consoles, smartphones, and other devices that can be used as 3D pointing devices contain a variety of magnets and magnetic materials that would distort the magnetic field measurements in *Bachmann*." PO Resp. 24 (citing Ex. 2015 ¶ 9). In particular, Professor LaViola opines that Yamashita's Wii Remote "contains such a speaker and other magnetic materials of the kind that would interfere with the sensor system and fusion method of *Bachmann*." Ex. 2015 ¶ 9. Such other magnetic materials would include, in his view, "many internal steel and gold parts, digital compasses, and often times the housing of such devices." *Id.*

Mr. Andrews disagrees. Ex. 1030 ¶ 45. First, he opines that Professor LaViola "does not elaborate on his general assertion that metal components may disrupt magnetic fields." Ex. 1030 ¶ 45. Rather, according to Mr. Andrews, a person of ordinary skill in the art "would have understood that the mere presence of metallic parts may or may not affect magnetic fields," particularly if the metal is non-ferrous. *Id.* Mr. Andrews also takes issue with Professor LaViola's opinion that digital compasses would affect the magnetic field, "since a digital compass would itself be the device used t[o] *measure* the magnetic field." *Id.*; *see also id.* ¶ 46 (describing how the digital compass used in the iPhone 4 included a calibration process to account for

localized effects of nearby magnetic components). Mr. Andrews also cites Professor LaViola's deposition testimony in which he agreed that gold is not magnetic, and that he believed (but was not sure) that non-magnetized steel is not magnetic. *Id.* ¶ 45 (citing Ex. 1028, 128:19–129:10).

Mr. Andrews also testifies that as of the filing date of the '438 patent, "numerous handheld devices were in existence that included magnetic field measurement capability, and these devices were designed in such a way that the magnetic measurement was not affected by the components of the device, or those components had no effect on such measurements." Ex. 1030 ¶ 45. In particular, he opines that "numerous devices were available that included both speakers and magnetic measurement devices." *Id.* ¶ 46; *see also id.* ¶ 63 (opining that in the ten years between Bachmann and the filing date of the '438 patent, integration of magnetometers in devices containing metal parts and speakers had become commonplace). Thus, Mr. Andrews opines that Professor LaViola's "assertion that [a person of ordinary skill in the art] would be disinclined to use the processing method described by Bachmann in the system of Yamashita because of concerns about magnetic interference are not supported by systems in common use at the time the '438 patent application was filed." *Id.* ¶ 47. Mr. Andrews also opines that the challenged claims do not require a speaker, so the speaker in Yamashita's device could simply be omitted in the Yamashita–Bachmann combination if it caused a problem. *See* Ex. 1030 ¶ 63.

We find the testimony of Mr. Andrews more persuasive on this point than that of Professor LaViola. We also note that the "Background of the Invention" section of the '558 provisional application states that "[c]ompensation to the accumulated error may be done by calibration with

reference to a magnetic direction . . . detected by a magneto-resistance . . . sensor equipped in the 3D pointing device," and gives examples of such calibration in the prior art. Ex. 2017 ¶ 4. This teaching is incorporated by reference into the '438 patent. *See* Ex. 1001, 1:7–11. Thus, the '438 patent acknowledges that it was known in the prior art to calibrate magnetic sensors to compensate for errors in the measured magnetic field direction.

Thus we find that the evidence does not support CyWee's argument that, as of the date of the claimed invention, a person of ordinary skill in the art would have been dissuaded from incorporating Bachmann's MARG sensor and filter into a device containing common magnetic components, such as speakers, found in Yamashita's device or other mobile devices such as smartphones.

Our finding is consistent with the Board's finding in *Google v. CyWee*, based on similar testimony by the petitioner's expert Professor Sarrafzadeh, that Bachmann does not teach away from adding sensors to devices that may include magnetic material, provided that such devices are not "made of" magnetic material in the sense that they produce a significant magnetic field, relative to the Earth's magnetic field. *See* IPR2018-01258, Paper 86, 36–37.

LGE also addressed this issue in its Opposition to CyWee's Revised Motion to Amend, and our finding is consistent with LGE's supporting testimony by Professor Michalson. Opp. RMTA 19–20 n.11 (citing Ex. 1051 ¶ 61, n.8 (testimony by Professor Michalson)). Professor Michalson considered Professor Sarrafzadah's testimony in *Google v. CyWee*, and concurs in his opinion. *See* Ex. 1051 ¶ 61 n.8 (citing Ex. 1058 ¶¶ 4–12 (Professor Sarrafzadah's testimony in *Google v. CyWee*)). According to Professor Michalson, "Bachmann's mention of 'non-magnetic materials'

(Ex. 1007, 13:45–46) does not teach away from the combinations proposed here." *Id.* Like Professor Sarrafzadah, he opines that "non-magnetic materials" only refers to "devices that would generate significant magnetic fields," and Bachmann's use of the term "made of" only "refers to a device encase[d] in a magnetic housing or something similar," but not devices such as smartphones, which "do not produce significant magnetic fields." *Id.* Although CyWee questioned the credibility of Professor Michalson's testimony in its Reply because he refers to himself in the third person, CyWee did not specifically rebut the substance of his testimony, which we find persuasive. *See* PO Reply RMTA 1; *supra* part II.D.3.

Next, CyWee argues, based on testimony by Professor LaViola, that a person of ordinary skill in the art would not have been motivated to combine Yamashita with Bachmann "because the claimed methods and apparatuses of the two patents are already complete solutions to the problem of correcting for errors in motion sensing that approach a problem with differing methods." PO Resp. 25 (citing Ex. 2001 ¶ 91).[28]

---

[28] In its Preliminary Response, CyWee also argued that combining Yamashita and Bachmann "would take undue experimentation to create an operable device." Paper 6, 36. The Board addressed this argument while instituting this *inter partes* review. *See* Paper 7, 24–25. However, this argument does not appear in the Patent Owner Response, so it appears that CyWee has abandoned it. *See* Paper 8, 8 ("Patent Owner is cautioned that any arguments for patentability not raised in the response may be deemed waived."); *see also In re NuVasive, Inc.*, 842 F.3d 1376, 1380–81 (Fed. Circ. 2016) (holding that a patent owner waived arguments that were not raised in its response after institution); CTPG 66 ("The [patent owner] response should identify all the involved claims that are believed to be patentable and state the basis for that belief."). Also, we find persuasive Mr. Andrews's testimony that CyWee's undue experimentation argument is irrelevant, given

This argument is not persuasive, because ZTE's combination is of Yamashita's game controller with Bachmann's sensors and filter. *See* Pet. 22; *see also* Ex. 1030 ¶ 59 (Mr. Andrews stating that the asserted combination is "Yamashita's game console device with Bachmann's sensors and filter calculations." (emphasis omitted) (quoting Ex. 1003 ¶ 84)). Thus, ZTE does not propose that a person of ordinary skill in the art would have needed to combine the tracking methods of Yamashita and Bachmann.

Moreover, Yamashita discloses that "[f]or calculating the estimated posture based on the acceleration and angular velocity, any method is usable." Ex. 1006, 19:8–10. Yamashita therefore invites the use of other posture estimation algorithms such as that of Bachmann, which, like Yamashita, estimates posture based on acceleration and angular velocity data. *See* Ex. 1006, Fig. 3.

In testimony that we find persuasive, Mr. Andrews also opines that Yamashita expresses a shortcoming in its tracking method when the device is moving. Ex. 1003 ¶ 84–85 (citing Ex. 1006, 19:29–40). He opines that "Bachmann, on the other hand, provides computation methods that allow[one to] compensate for errors when the device is moving." Ex. 1030 ¶ 65. We also find Mr. Andrews's testimony persuasive that Bachmann's filter is "a more efficient error control algorithm" than that of Yamashita because Bachmann uses "a feedback system." *Id.*

Finally, CyWee argues that Bachmann was "only identified through the impermissible application of hindsight bias," because Mr. Andrews "testified that he searched for prior art based on a study of the '438 patent."

---

that the Yamashita–Bachmann combination does not require combining the two references in the way that CyWee suggests. Ex. 1030 ¶ 62.

PO Resp. 26 (citing Ex. 2016, 228:11–15). According to CyWee, "[u]sing the patent as a template to identify the prior art is an example of impermissible hindsight bias." *Id.* (citing *Ecolochem, Inc. v. S. Cal. Edison Co.*, 227 F.3d 1361, 1371–72 (Fed. Cir. 2000)).

We disagree that ZTE's patent search involved impermissible hindsight. It is permissible to study the challenged patent before searching for relevant prior art, because the scope of the claimed invention determines the scope of the relevant prior art. Improper hindsight does not relate to the prior art search, but to the way in which one combines the prior art references, once identified: "so long as [a reconstruction of prior art] takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made and does not include knowledge gleaned only from applicant's disclosure, such a reconstruction is proper." *In re McLaughlin*, 443 F.2d 1392, 1395 (CCPA 1971). *Ecolochem* does not suggest otherwise. In that case, the Federal Circuit held that there was improper hindsight, not because the patent challenger used the patent as a guide to identify relevant prior art, but because the district court improperly used the challenged patent as a blueprint to combine the *identified* prior art without discussing any specific evidence of a motivation to combine. *See* 227 F.3d at 1372.

Based on all the above evidence, we find that a person of ordinary skill in the art would have had reason to combine Yamashita's pointing device with Bachmann's filter and sensors. We discuss that motivation in more detail, below, with respect to the individual claim limitations.

5. Comparison of the Challenged Claims with Yamashita and Bachmann.

The Petition includes a limitation-by-limitation analysis comparing the challenged claims with Yamashita and Bachmann. Pet. 31–60. Based on ZTE's analysis, and taking into consideration CyWee's opposing arguments and evidence, we find that ZTE has shown by a preponderance of the evidence that the combination of Yamashita and Bachmann teaches each limitation of challenged claims 1, 4, 5, 14–17, and 19.

(a) Claim 1 preamble

The preamble of claim 1 recites "[a] three-dimensional (3D) pointing device subject to movements and rotations in dynamic environments." Ex. 1001, 18:54–55. Supported by testimony of Mr. Andrews, ZTE contends that Yamashita discloses 3D pointing device as recited in the preamble. Pet. 31–33 (citing Ex. 1006, 9:42–50, 12:47–13:10, 13:61–65, 14:35–48, Figs. 1, 3, 8; Ex. 1003 ¶ 112–113).

CyWee does not contest ZTE's argument, *see* PO Resp. 27, and we find it persuasive. Because we find that Yamashita discloses the preamble of claim 1, we need not determine whether the preamble is limiting.[29]

(b) Limitation 1(a)

Limitation 1(a) recites "a housing associated with said movements and rotations of the 3D pointing device in a spatial pointer reference frame."

[29] As we discuss above, both Mr. Andrews and Professor LaViola opine that at least the phrase "three dimensional (3D) pointing device" in the preamble is limiting. *See* Ex. 1003 ¶ 55; Ex. 2001 ¶ 47. However, we do not construe that term for this decision. *See supra* part IV.B.1.

Ex. 1001, 18:57–59. Supported by testimony of Mr. Andrews, ZTE contends that Yamashita discloses a housing as recited in this limitation. Pet. 33–35 (citing Ex. 1006, 9:42–10:7, Figs. 3, 4, 7; Ex. 1003 ¶ 116).

We find ZTE's argument persuasive, and CyWee does not contest that Yamashita discloses this limitation. *See* PO Resp. 27.

(c) Limitation 1(b)

Limitation 1(b) recites "a printed circuit board (PCB) enclosed by the housing." Ex. 1001, 18:60. Supported by testimony of Mr. Andrews, ZTE contends that Yamashita discloses a printed circuit board as recited in this limitation. Pet. 35–36 (citing Ex. 1006, 10:38–44, Figs. 5, 6; Ex. 1003 ¶ 117; Ex. 1002, 80 ("Examiner takes Official Notice that it was well known in the art to employ the use of a PCB to mechanically support and electrically connect electronic components using conductive pathways.")).

We find ZTE's argument persuasive, and CyWee does not contest that Yamashita discloses this limitation. *See* PO Resp. 27.

(d) Limitations 1(c)–(e)

Limitations 1(c)–(e) recite the following:

[1(c)] a six-axis motion sensor module attached to the PCB, comprising

[1(d)] a rotation sensor for detecting and generating a first signal set comprising angular velocities ω_x, ω_y, ω_z associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame,

[1(e)] an accelerometer for detecting and generating a second signal set comprising axial accelerations Ax, Ay, Az associated with said movements and

> rotations of the 3D pointing device in the spatial pointer reference frame . . . .

Ex. 1001, 18:61–19:3 (ZTE's reference numbers and line formatting added). ZTE contends that Yamashita discloses limitation 1(c), and a combination of Yamashita and Bachmann teaches limitations 1(d) and 1(e). Pet. 36–40.

In particular, with respect to limitation 1(c), ZTE argues that Figures 5–7 of Yamashita "show that the acceleration sensor 37 is attached to the substrate, which is the PCB, and gyrosensors 55 and 56 reside in the gyrosensor unit 7, which can be attached to the PCB," and "once the gyrosensor unit is plugged to the controller, the gyrosensor unit is attached to the PCB directly." Pet. 36 (citing Ex. 1006, 10:36–11:32, Figs. 5–7; Ex. 1003 ¶ 120). ZTE also argues that acceleration sensor 37 detects three axes of acceleration, gyrosensors 55 and 56 detect three axes of angular velocities, "[t]hus, in total, Yamashita discloses a six-axis motion sensor." Pet. 36–37 (citing Ex. 1006, 12:47–13:10, 14:35–48, Fig. 8; Ex. 1003 ¶ 121).

CyWee argues that since limitations 1(d) and 1(e) specify that the six-axis motion sensor comprises both a rotation sensor and an accelerometer, limitation 1(c) requires that both sensors are attached to the same PCB. PO Resp. 27–28.

CyWee also contends that both references teach away from limitation 1(c). *Id.* at 28 (citing Ex. 2001 ¶¶ 95–98). According to CyWee, Yamashita teaches away from limitation 1(c) because its accelerometers and imagers are attached to the same circuit board, while the gyroscopes are located in a separate, detachable gyrosensor unit with its own microcontroller. *Id.* (citing Ex. 1006, 10:38–50, 10:54–61, 11:14–17, 14:28–34; Ex. 2001 ¶¶ 61–62).

Thus, CyWee argues that Yamashita "expressly teaches that its gyrosensors are *not* to be attached to the circuit board." *Id.*

Similarly, CyWee contends that Bachman teaches away from limitation 1(c) because it teaches that the individual components of the MARG sensor "can be integrated using a single integrated circuit board with the accelerometers mounted separately." PO Resp. 28 (citing Ex. 1007, 14:49–51). Thus, CyWee argues that Bachmann "teaches that its accelerometers should not be mounted on the circuit board." *Id.* (citing Ex. 2001 ¶ 69).

CyWee's argument is unpersuasive in light of our construction of the term "attached to the PCB" to mean "attached to one or more PCBs." *See supra* part IV.B.5. This renders CyWee's teaching-away arguments moot.

CyWee's argument would also be unpersuasive if we had adopted a narrower construction of "attached to the PCB." While CyWee contends that Yamashita and Bachmann do not disclose a six-axis motion sensor module attached to a single PCB, CyWee does not explain how the particular embodiments in either Yamashita or Bachmann would have dissuaded a person of ordinary skill in the art from combining the sensors on a single PCB rather than on separate PCBs. *See DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1327 (Fed. Cir. 2009) ("A reference does not teach away . . . if it merely expresses a general preference for an alternative invention but does not 'criticize, discredit, or otherwise discourage' investigation into the invention claimed." (quoting *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004)).

Other than as discussed above, CyWee does not challenge ZTE's arguments regarding limitations 1(d) and 1(e). *See* PO Resp. 27. For

limitation 1(d), ZTE argues that Yamashita discloses the recited three-axis rotation sensor. Pet. 37 (citing Ex. 1006, 3:53–4:7, 4:10–25; Ex. 1003 ¶¶ 122–23). ZTE also argues that Bachmann discloses the recited rotation sensor, and that a person of ordinary skill in the art would have been motivated to use Bachmann's sensor in Yamashita's handheld game controller. *Id.* at 37–38 (citing Ex. 1007, 9:59–10:14, 10:10–14, 10:17–30, Fig. 3; Ex. 1003 ¶¶ 126–127). We find these arguments persuasive.

For limitation 1(e), ZTE argues that Yamashita discloses the recited three-axis accelerometer. PO Resp. 39 (citing Ex. 1006, 12:47–13:10, 17:52–18.2, Fig. 3). ZTE also argues that Bachmann discloses the recited accelerometer, and that a person of ordinary skill in the art would have been motivated to use Bachmann's sensor in Yamashita's handheld game controller. *Id.* at 39–40 (citing Ex. 1007, 8:12–42, 10:10–14, Fig. 3; Ex. 1003 ¶ 130). We find these arguments persuasive.

In sum, we find that ZTE has shown that Yamashita discloses limitation 1(c), and that a person of ordinary skill in the art would have been motivated to use Bachmann's rotation sensor and accelerometer in Yamashita's game controller to obtain limitations 1(d) and 1(e).

(e) Limitations 1(f)–(h)

Limitation 1(f) recites "a processing and transmitting module" with the characteristics set forth in the remainder of claim 1. Ex. 1001, 19:4. Of these characteristics, limitations 1(g) and 1(h) relate to the hardware of this module. *See id.* at 19:4–18. ZTE contends that Yamashita discloses each of these aspects of the processing and transmitting module. *See* Pet. 40–42.

In particular, limitation 1(g) recites "a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting

said first and second signal sets thereof." Ex. 1001, 19:4–7. ZTE argues that Yamashita discloses this limitation because the game controller has a communication section (box 36 in Figure 7) that electronically connects to the sensors and transmits the signals from each sensor. Pet. 40–42 (citing Ex. 1006, 11:52–59, 12:62–13:24, 14:18–27, 14:28–15:8, Fig. 7; Ex. 1003 ¶ 132).

Limitation 1(h) recites "a computing processor for receiving and calculating said first and second signal sets from the data transmitting unit." Ex. 1001, 19:7–9. ZTE argues that Yamashita discloses this limitation because the game controller has a microcomputer (box 42 in Figure 7) that receives and processes the signals from each sensor. Pet. 42 (citing Ex. 1006, 12:62–13:60, 14:18–15:14, Fig. 7).

We find ZTE's argument as to limitations 1(f)–(h) persuasive, and CyWee does not contest that Yamashita discloses these limitations. *See* PO Resp. 27.

(f) Limitation 1(i)

Limitations 1(i)–(k) relate to functional aspects of the recited "processing and transmitting module" (limitation 1(f)). Ex. 1001, 19:4–18. In particular, limitation 1(i) recites "communicating with the six-axis motion sensor module to calculate a resulting deviation comprising resultant angles in said spatial pointer reference frame." Ex. 1001, 19:9–12. ZTE argues that Yamashita discloses this limitation because the game controller calculates orientation angles in the game controller's reference frame. Pet. 43 (citing Ex. 1006, 12:62–13:24, 14:18–15:8, Figs. 7, 8). According to ZTE, "resulting deviation" means the orientation of the pointing device. *Id.* (citing Ex. 1001, 1:58–61; Ex. 1003 ¶ 137). We find ZTE's arguments persuasive.

ZTE also argues, and we agree, that Bachmann teaches a "resulting deviation" in the form of predicted orientation quaternion $\hat{q}$ in Figure 3. *Id.* at 48 (citing Ex. 1007, Fig. 3; Ex. 1003 ¶ 153). Although $\hat{q}$ is in quaternion form, ZTE persuasively argues that it would have been within the ordinary skill in the art convert $\hat{q}$ into Euler angles representing roll, pitch, and yaw for use in Yamashita's controller, which uses Euler angles. *See* Pet. 43 (citing Ex. 1006, 14:35–48, Fig. 8); Ex. 1006, 21:65–22:20, 22:54–24:30; Ex. 1007, 7:6–31; *see also* IPR2018-01258, Paper 86, 49 (finding that it would have been obvious to calculate roll, pitch, and yaw angles from Bachmann's orientation quaternion $\hat{q}$).

Also, ZTE acknowledges that in Bachmann, the sensor measurements are taken in the spatial pointer reference frame, but then converted to the "earth" or "world" reference frame for the comparison and integration operations to obtain resulting deviation $\hat{q}$. *See* Pet. 48–49; Ex. 1003 ¶¶ 154, 156. However, ZTE contends that it would have been an obvious variation to reverse the order of the two operations, so that the comparison and integration calculations are performed first in the sensor reference frame first, and then converted to the world reference frame after obtaining $\hat{q}$. *See* Pet. 48–49 (citing Ex. 1003 ¶ 156). According to ZTE, "this change in the sequence of operations does not have any impact on the result." *Id.* (citing Ex. 1030 ¶ 156). We find this persuasive. We also credit Mr. Andrews's testimony that "the process of changing reference frames using quaternion multiplication is independent of the quantities that are to be transformed," and that performing Bachmann's operations in the spatial pointer reference frame would have been beneficial because "doing so would result in a reduction o[f] coordinate conversion steps, since the output quaternion

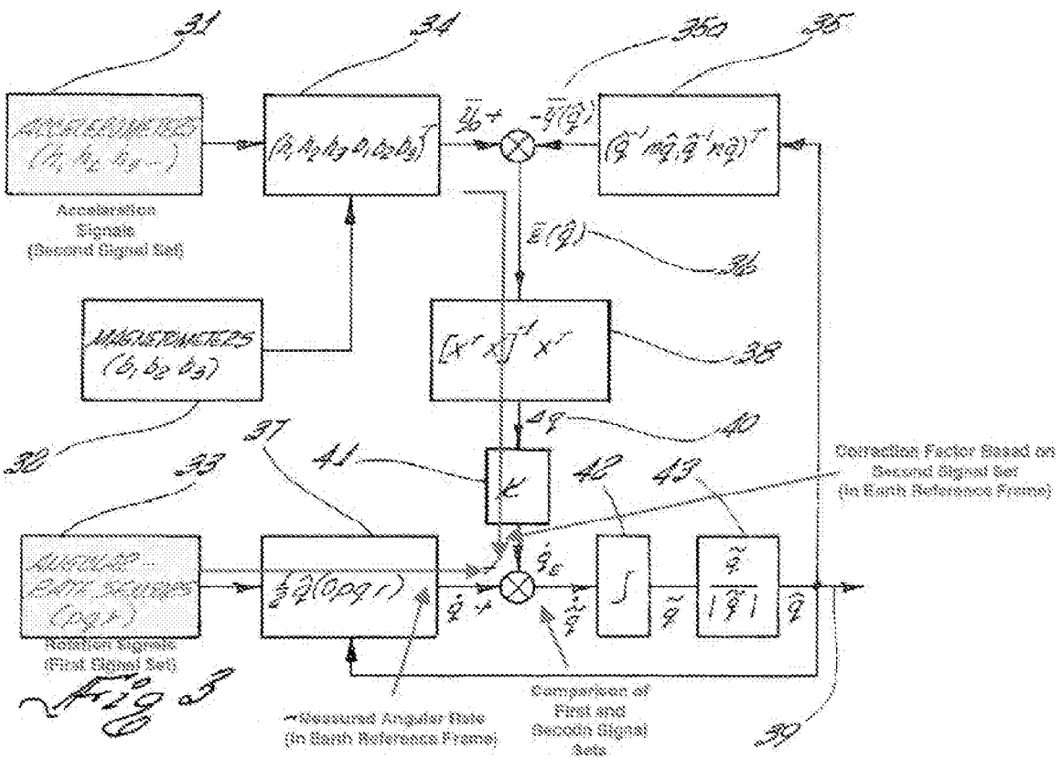
would not need to be subsequently rotated back to the spatial reference frame in step 35." Ex. 1030 ¶ 154; *see also id.* ¶ 43, 155–156.

Other than CyWee's general arguments about whether a person of ordinary skill in the art would have combined Yamashita with Bachmann, which we discuss above, CyWee does not contest ZTE's arguments regarding limitation 1(i). *See* PO Resp. 27; *supra* part IV.C.4. We find for the above reasons that Yamashita discloses limitation 1(i), and that in light of Yamashita's teachings, a person of ordinary skill in the art would have been motivated to modify Bachmann's filter to obtain a resulting deviation comprising resultant angles in the spatial pointer reference frame.

(g) Limitation 1(j)

Limitation 1(j) recites "by utilizing a comparison to compare the first signal set with the second signal set." Ex. 1001, 19:12–14. ZTE argues that Yamashita discloses limitation 1(j) by the algorithm in Yamashita's Figure 23 (reproduced in relevant part above). Pet. 43–44 (citing Ex. 1006, 19:1–13, Fig. 23); *see supra* part IV.C.1.

ZTE also argues that Bachmann discloses limitation 1(j), and that a person of ordinary skill in the art would have been motivated to use Bachmann's sensor and filter with Yamashita's game controller. Pet. 44–48. According to ZTE, the recited "comparison" between the first signal set and the second signal set takes place in Bachmann at the point where measured rate quaternion $\dot{q}$ is corrected using correction factor $\dot{q}_\varepsilon$, as illustrated in a version of Bachmann's Figure 3 annotated by Petitioner, reproduced below:



Pet. 48; Ex. 1003 ¶ 154. In annotated Figure 3, above, angular rate sensor data (p, q, r) in box 33 is labeled as the "First Signal Set," and accelerometer data (h_1, h_2, h_3) in box 31 is labeled as the "Second Signal Set." Rate quaternion $\dot{q}$ is labeled as "Measured Angular Rate (in Earth Reference Frame)," and correction factor $\dot{q}_\varepsilon$ is labeled as "Correction Factor Based on Second Signal Set (in Earth Reference Frame)." The annotated figure labels the point where $\dot{q}$ is added to $\dot{q}_\varepsilon$ as "Comparison of First and Seco[nd] Signal Sets." There are two large arrows highlighting the flow of calculation, which converge at this alleged comparison point: (1) an arrow from box 34 (containing the accelerometer data) and passing through the comparison between $\vec{y}_0$ and $\vec{y}(\hat{q})$ and boxes 38 and 41; and (2) an arrow from box 33 (the angular rate data) passing through box 37.

ZTE walks through Bachmann's filter method and shows how rate quaternion $\dot{q}$ is based on angular rate sensor data (p, q, r) (the first signal set), and how correction factor $\dot{q}_\varepsilon$ is ultimately derived from accelerometer data (h_1, h_2, h_3) (the second signal set). *See* Pet. 45–48 (citing Ex. 1007, 8:37–42, 8:63–9:48, 9:59–10:14, 17:12–22, Fig. 3; Ex. 1003 ¶¶ 141, 144–153). Thus, in sum, ZTE contends that the recited "comparison" occurs when rate quaternion $\dot{q}$, derived from the first signal set, is compared with the accelerometer data (the second signal set) via correction factor $\dot{q}_\varepsilon$. See Pet. 48 (annotated Fig. 3).

Alternatively, ZTE identifies a comparison as occurring at the top of Figure 3 at the point where measurement vector $\vec{y}_0$ is compared to computed measurement vector $\vec{y}(\hat{q})$. Pet. 47 (citing Ex. 1007, 9:9–17, 17:12–22; Ex. 1003 ¶ 149); ZTE Reply 14–15. ZTE contends that computed measurement vector $\vec{y}(\hat{q})$ is derived from the first signal set (the corrected angular velocities) and measurement vector $\vec{y}_0$ is derived from the second signal set (the measured axial accelerations); thus, ZTE argues that it meets the characteristics of the recited comparison. ZTE Reply 15–17.

This alternative argument is consistent with the Board's finding in *Google v. CyWee* that the comparison between $\vec{y}_0$ and $\vec{y}(\hat{q})$ meets the "comparison" limitation in claim 1. *See* IPR2018-01258, Paper 86, 50–53. This alternative argument is also the approach that LGE takes in its Opposition to the Revised Motion to Amend. *See* Opp. RMTA 21 (limitation 20(g)); *infra* part V.D.2(c)(3).

Given the scope of our construction of the term "comparison" in the '438 patent, we find that both of ZTE's alternative arguments are persuasive. As discussed above, we construe the term "comparison" as "the calculating

and obtaining of the actual deviation angles of the 3D pointing device . . . with respect to the first reference frame or spatial pointing frame X_P Y_P Z_P utilizing signals generated by motion sensors while reducing or eliminating noises associated with said motion sensors," which is based on an explicit definition in the '438 patent. *See supra* part IV.B.4. Both of the locations that ZTE identifies in Bachmann's Figure 3 meet this definition, except to the extent that Bachmann teaches that resulting deviation $\hat{q}$ (39) is calculated in the "world" or "earth" reference frame. But as we discuss above in the context of limitation 1(i), we find that a person of ordinary skill in the art would have had reason, in light of Yamashita, to perform Bachmann's calculations in the spatial pointer reference frame. *See supra* part IV.C.5(f).

Further, ZTE has persuasively shown, in both of its arguments, that the comparison is with respect to the first signal set (the angular velocities) and the second signal set (the axial accelerations) as recited in limitation 1(j), and that the comparison "utilize[es] signals generated by motion sensors while reducing or eliminating noises associated with said motion sensors," according to our construction. In ZTE's first argument, the comparison does so by using correction factor $\dot{q}_\varepsilon$, based in part on the accelerometer data (second signal set), to update rate quaternion $\dot{q}$ and correct for noise associated with angular rate sensor data (p, q, r) (the first signal set). *See* Ex. 1007, 9:55–58, 10:36–45, Fig. 3. In ZTE's second argument, the comparison does this by directly comparing measurement vector $\vec{y}_0$ (comprising data from the second signal set) with computed measurement vector $\vec{y}(\hat{q})$ (derived from the first signal set) to ultimately calculate correction factor $\dot{q}_\varepsilon$. *See* Pet. 47 (citing Ex. 1007, 9:9–17, 17:12–22; Ex. 1003 ¶ 149); ZTE Reply 14–17.

Other than CyWee's arguments about whether a person of ordinary skill in the art would have combined Yamashita with Bachmann, which we discuss above, CyWee does not contest ZTE's arguments regarding limitation 1(j). *See* PO Resp. 27; *supra* part IV.C.4. We find that the combination of Yamashita and Bachmann teaches limitation 1(j), and that a person of ordinary skill in the art would have had reason to combine the two references to obtain limitation 1(j).

(h) Limitation 1(k)

Limitation 1(k) recites "said resultant angles in the spatial pointer reference frame of the resulting deviation of the six-axis motion sensor module of the 3D pointing device are obtained under said dynamic environments." Ex. 1001, 19:15–18. ZTE argues that both Yamashita and Bachmann disclose this limitation. Pet. 48–49 (citing Ex. 1003 ¶ 156).

Other than CyWee's arguments about whether a person of ordinary skill in the art would have combined Yamashita with Bachmann, which we discuss above, CyWee does not contest ZTE's arguments regarding these limitations. *See* PO Resp. 27; *supra* part IV.C.4.

We find that ZTE has shown that the combination of Yamashita and Bachmann discloses limitation 1(k), for the reasons given above with respect to limitations 1(i) and 1(j).

(i) Limitation 1(l)

Limitation 1(l) recites "wherein the comparison utilized by the processing and transmitting module further comprises . . . ." Ex. 1001, 19:18–20. This limitation is a prelude to both limitations 1(m) and 1(n), and ZTE relies on its arguments for those limitations. *See* Pet. 73. CyWee agrees

that ZTE's arguments for 1(l) depend on its arguments for 1(m)–(n). PO Resp. 29. For the reasons below, we find that the Yamashita–Bachmann combination teaches limitations 1(m) and 1(n), and thus 1(l).

(j) Limitation 1(m)

Limitation 1(m) recites "an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set." Ex. 1001, 19:20–23. ZTE contends that Yamashita meets this limitation by disclosing that "the updated posture, which is the updated state, is based on the angular velocity, the first signal set, and corrected by acceleration data, the second signal set." Pet. 49 (citing Ex. 1006, 19:8–13, 19:29–40; Ex. 1003 ¶ 158).

CyWee disagrees, arguing that "*Yamashita* at most discloses using angular velocity and acceleration data taken at the *current time*, . . . and makes no mention of obtaining the updated posture based on a previous state associated with the angular velocities *at a previous time*." PO Resp. 30 (citing Ex. 1006, 19:29–40). We find CyWee's argument persuasive, because ZTE has not shown that Yamashita's sensor fusion method includes a feedback loop that updates the state based on the previously calculated state.

Alternatively, ZTE relies on Bachmann for teaching limitation 1(m). *See* Pet. 50–51; ZTE Reply 15–20. In particular, ZTE points to equation 16 of Bachmann,

$$\hat{q}_{n+1} = \hat{q}_n + \frac{1}{2}\hat{q}^B\omega\Delta t + \alpha[X^TX]^{-1}X^T\varepsilon(\hat{q}_n)$$
$$\hat{q}_n + k\Delta t\Delta q_{full} + \dot{q}_{measured}\Delta \mathrm{t}$$

which, according to ZTE, "clearly shows that the next discrete value of q [the updated state] is determined by the least squares filtered difference

'Δq_{full}' times the time interval between the samples plus the measured angular rate time[s] the time interval." Pet. 50–51 (citing Ex. 1003 ¶ 161); *see also* Ex. 1030 ¶¶ 88–94 (Mr. Andrews explaining his testimony in more detail in support of ZTE's Reply). In other words, according to Mr. Andrews, equation 16

> clearly shows that the next discrete value of $\hat{q}$, $\hat{q}_{n+1}$ is determined by previous state $\hat{q}_n$, the measured angular velocity (first signal set) quaternion integrated over time Δt, $\frac{1}{2}\hat{q}^B\omega\Delta t$, and an error term $\varepsilon(\hat{q}_n)$ that is derived by the difference between the quaternion formed by the measured acceleration (second signal set) and magnetic orientation, and the prior orientation quaternion rotated from the sensor frame to the world frame, which is $\bar{y}(\hat{q})$.

Ex. 1030 ¶ 89.

In response to ZTE's alternative argument, CyWee argues that "the only discussion of actual measurements and the computed measurement in *Bachmann* is with respect to the 6×1 measurement vector, and this measurement vector involves two unit vector quaternions combining both the magnetometer and the accelerometer measurements." PO Resp. 30–31 (citing Ex. 2007, 8:53–50, 9:13; Ex. 2016, 173:2–6). According to CyWee, Bachmann's equation 16 does not support ZTE's position because "the process claimed by the '438 Patent and by which the '438 Patent obtains its updated state is very different from that *actually* disclosed by *Bachmann*," which uses Gauss-Newton iteration for filter processing rather than elements of an extended Kalman filter. *Id.* at 31–32 (citing Ex. 1001, 13:51–14:22; Ex. 1007, 9:20–37, Fig. 3; Ex. 1014, 94, 101; Ex. 2015 ¶ 14). Thus, CyWee argues that Bachmann is not enabling. *Id.* at 32 (citing *Impax Labs, Inc. v. Aventis Pharms. Inc.*, 468 F.3d 1366, 1381 (Fed. Cir. 2006); Ex. 2015 ¶ 14).

We find ZTE's alternative argument regarding limitation 1(m) persuasive. Bachmann's Equation 16 indicates that $\hat{q}_{n+1}$ (the updated state quaternion at time $n+1$), is based on $\hat{q}_n$ (the previous state quaternion at time n) in two ways, via the terms $\hat{q}_n$ and $\alpha[X^T X]^{-1}X^T\varepsilon(\hat{q}_n)$. Previous state $\hat{q}_n$ is associated (in the iteration of equation 16 for the previous time step) with the first signal set via the term $\frac{1}{2}\hat{q}^B\omega\Delta t$ or $\dot{q}_{measured}\Delta$t, which derives from angular rate data (p, q, r). *See* Ex. 1030 ¶ 90; *see also* ZTE Reply 19 (showing this relationship in graphical form as an annotated version of Bachmann's Figure 3). As limitation 1(m) also requires, updated state $\hat{q}_{n+1}$ is based on a measured state associated with the second signal set via term $\alpha[X^T X]^{-1}X^T\varepsilon(\hat{q}_n)$ or $k\Delta t\Delta q_{full}$, for the reasons discussed below under limitation 1(n). *See infra* part IV.C.5(k).

We do not find persuasive CyWee's argument that Bachmann lacks enablement as to limitation 1(m). First, while an anticipatory reference must be enabling, in the context of determining obviousness under § 103 we consider the prior art teachings as a whole, including subject matter that is allegedly inoperative or non-enabling. *Symbol Techs. Inc. v. Opticon Inc.*, 935 F.2d 1569, 1578 (Fed. Cir. 1991) (explaining that "a non-enabling reference may qualify as prior art for the purpose of determining obviousness"). Second, we are not persuaded by CyWee's suggestion that using elements of an extended Kalman filter would have been outside the level of ordinary skill in the art at the time of the claimed invention, because none of the challenged claims require using elements of an extended Kalman filter. *See In re Hiniker Co.*, 150 F.3d 1362, 1368–69 (Fed. Cir. 1998) (holding that characteristics found in the written description, but not in the claims, are not considered in an obviousness analysis).

Thus, having considered the arguments on both sides, we find that the Yamashita–Bachmann combination teaches limitation 1(m).

(k) Limitation 1(n)

Limitation 1(n) recites "wherein the measured state includes a measurement of said second signal set and a predicted measurement obtained based on the first signal set without using any derivatives of the first signal set." Ex. 1001, 19:23–26. ZTE contends that Yamashita discloses this limitation for the same reasons Yamashita discloses limitation 1(m). Pet. 51. As we discuss above, we find this argument unpersuasive. *See supra* part IV.C.5(j). In addition, as CyWee notes, Mr. Andrews conceded in his deposition that his opinion relies on Bachmann, not Yamashita, to teach a "predicted measurement" according to limitation 1(n). *See* PO Resp. 33 (citing Ex. 2016, 112:15–114:3).[30]

Alternatively, ZTE relies on Bachmann for teaching limitation 1(n). *See* Pet. 52–53; ZTE Reply 20–23. According to ZTE, the least-squares-filtered difference Δq_{full} in equation 16 "is determined . . . by comparing the

[30] CyWee argues that because Yamashita uses "angular accelerations," which are "derivatives of the first signal set," Yamashita "teaches away from a comparison method and update program that operates 'without using any derivatives of the first signal set.'" PO Resp. 33 (citing Ex. 1004, 21:28–30, 22:31–39, Figs. 23, 25). Although we do not rely on Yamashita for teaching limitation 1(n), we disagree that Yamashita's use of such derivatives constitutes a teaching away. CyWee has not explained why the use of derivatives in Yamashita's algorithm would have dissuaded a person of ordinary skill in the art from using a *different* algorithm without such derivatives.

output state $\hat{q}$ (in . . . the earth reference frame), that is, $[\bar{y}(\hat{q})]$,[31] against the measured state based on the accelerometers and the magnetometers, that is, y_0," to generate the error between the two values *Id.* at 52. ZTE contends that the entire computation for generating the error correction term from y_0 and $\bar{y}(\hat{q})$ "is in angular space, not in rate space. Thus, this predicted orientation is determined without using any derivatives." Pet. 53 (citing Ex. 1003 ¶ 167).

CyWee argues that Bachmann fails to "teach 'a predicted measurement' of the axial acceleration using information from the first signal set at time T." PO Resp. 33. According to CyWee, Mr. Andrews does not identify "which teachings from *Bachmann* disclose 'a predicted measurement," other than arguably the predicted value of q, "and, at best, that corresponds to an updated orientation, q, not a predicted axial acceleration, as required by Claim 1." *Id.* (citing Ex. 1003 ¶¶ 163–167).

We agree with CyWee that ZTE was unclear in its Petition which variable is the predicted measurement. Although ZTE mentions the calculation of $\bar{y}(\hat{q})$, ZTE seems to suggest that the recited "predicted measurement" is the updated $\hat{q}_{n+1}$ in Bachmann's equation 16. However, ZTE clarified this ambiguity in its Reply, stating that "$\bar{y}(\hat{q})$ (in . . . box 35a)

[31] In the Petition, the passage quoted here reads "$y_0(\hat{q})$" in arguments directed to limitations 1(m) and 1(n). Pet. 51–52. CyWee argues that ZTE is "creating its own evidence to support its position" because $y_0(\hat{q})$ "does not appear in the entire *Bachmann* reference." PO Resp. 31 (as to limitation 1(m)); *see also id.* at 34 (reiterating the argument as to limitation 1(n)). Given the context, it is clear that ZTE was referring to $\bar{y}(\hat{q})$ as shown in Figure 3. *See* Ex. 1030 ¶ 87 (Mr. Andrews acknowledging that there is no $y_0(\hat{q})$ in Bachmann, but that in light of the context of his discussion of Bachmann's Figure 3, "it is clear that this quantity should be $\bar{y}(\hat{q})$").

is the predicted axial acceleration and magnetic orientation quaternion based on the first signal set." ZTE Reply 22. Mr. Andrews further opined that a person of ordinary skill in the art "would have understood that subtraction of any two quantities requires that the quantities be of the same type," so "error term $\varepsilon(\hat{q}_n) = \bar{y}_0 - \bar{y}(\hat{q})$ must include both axial accelerations and magnetic orientations." Ex. 1030 ¶ 97. Thus, in his opinion, "$\bar{y}_0$ represents the current measured values for these quantities, and $\bar{y}(\hat{q})$ represents the same quantities derived from the prior predicted state." *Id.*

In its Sur-reply, CyWee disagrees that $\bar{y}(\hat{q})$ is the "predicted measurement" for two reasons. First, CyWee contends that Bachmann "does not describe $\bar{y}(\hat{q})$ as predicted measurements; it does not provide any description at all." PO Sur-reply 12 (citing Ex. 1007).

We do not find this argument persuasive. Bachmann describes $\bar{y}(\hat{q})$ (or the synonymous symbol $\vec{y}(\hat{q})$[32]) as a "computed measurement vector." Ex. 1007, 9:2, 9:10. Bachmann also states that $\vec{y}_0$ (synonymous with $\bar{y}_0$) "is considered a vector of data points and $\vec{y}(\hat{q})$ is a vector to be fitted to those points" based on linearized least square regression analysis. *Id.* at 9:32–35. We see no substantive difference between a "predicted measurement" and a vector described as a "computed measurement" that is fitted by regression to a set of actual measurements.

Second, CyWee argues that ZTE "identified the output of Box 34 as 'the measured state associated with said second signal set of axial

[32] *See* Ex. 1051 ¶ 64 n.9 (Professor Michalson explaining that $\bar{y}(\hat{q})$ and $\vec{y}(\hat{q})$ are interchangeable).

accelerations' but $\vec{y}(\hat{q})$ (the quantity alleged by Petitioner to be the claimed 'predicted measurement') is not part of Box 34." PO Sur-reply 12.

We do not find this argument persuasive. Read fairly, ZTE's argument in the Reply, and Mr. Andrews's supporting testimony, are that $\bar{y}_0$ is the recited "measurement of said second signal set," that $\bar{y}(\hat{q})$ is the recited "predicted measurement obtained based on the first signal set without using any derivatives of the first signal set," and that $\bar{y}_0$ and $\bar{y}(\hat{q})$, together, comprise the "measured state associated with said second signal set."

Based on all the evidence of record, we find that ZTE has shown that Bachmann teaches limitation 1(n). In particular, ZTE has shown that $\bar{y}_0$ and $\bar{y}(\hat{q})$ correspond to the "measured state." There is nothing in claim 1 that requires the "measured state" to consist of a single variable, and in the '438 patent itself, measurement Ax, Ay, Az and predicted measurement Ax′, Ay′, Az′ are, likewise, distinct entities. *See* Ex. 1001, 12:61–13, 13:31–37; Ex. 1048, 156:17–167:15 (Professor LaViola explaining how the '438 patent supports the "measurement" and "predicted measurement" limitations). Like calculated measurements $\bar{y}(\hat{q})$ in Bachmann, predicted measurements Ax′, Ay′, Az′ are "obtained based on or calculated from the first signal set." Ex. 1001, 8:52–56. We also agree with ZTE that Bachmann's $\bar{y}(\hat{q})$ is calculated without using any derivatives of the first signal set.[33]

For all the above reasons, we find that the Yamashita–Bachmann combination teaches all the limitations of claim 1, and that a person of ordinary skill in the art would have been motivated to combine the teachings

[33] We also address some of the above issues below, in the context of CyWee's Revised Motion to Amend. *See infra* part V.D.2(c)(4).

of the references as recited in claim 1. Therefore, we conclude that claim 1 is unpatentable under § 103 as obvious over Yamashita in light of Bachmann.

(l) Claim 4

Claim 4 depends from claim 1 and recites "wherein the spatial pointer reference frame is a reference frame in three dimensions; and wherein said resultant angles of the resulting deviation includes yaw, pitch and roll angles about each of three orthogonal coordinate axes of the spatial pointer reference frame." Ex. 1001, 19:37–42.

ZTE argues that Yamashita discloses the new limitations of claim 4 by disclosing that the pointing device "is capable of detecting movements and rotations in a three-dimensional coordinate system" and that "the resultant angles would be yaw, pitch and roll angles." Pet. 53 (citing Pet. 36–37, 43, 48–49; Ex. 1006, 12:62–13:10).

ZTE also argues that Bachmann discloses the new limitations because it discloses a "body coordinate system" with three orthogonal axes. Pet. 54 (citing Ex. 1007, 5:49–6:10; Ex. 1003 ¶ 169).

CyWee does not contest ZTE's arguments regarding claim 4, other than to argue in general that ZTE has failed to show that the Yamashita–Bachmann combination discloses all the elements of parent claim 1 and "discloses all elements of any claims depending from Claim 1." PO Resp. 34.

We find ZTE's arguments persuasive. Thus, we conclude that claim 4 is unpatentable under § 103 as obvious over Yamashita in light of Bachmann.

(m) Claim 5

Claim 5 depends from claim 1 and recites "wherein the data transmitting unit of the processing and transmitting module is attached to the PCB enclosed by the housing and transmits said first and second signal of the six-axis motion sensor module to the computing processor via electronic connections on the PCB." Ex. 1001, 19:43–48.

ZTE argues that Yamashita discloses this limitation because, on the PCB inside the housing, "[t]he data transmitting unit is between the sensors and the processor, and must be electrically connected." Pet. 55 (citing Ex. 1006, Figs. 3, 4, 7; Ex. 1003 ¶ 172). ZTE also argues that "[i]t would have been obvious to attach the transmitting unit to the PCB and use the traces," because when electronic systems contain components that communicate with each other, "[t]hose electrical signals must travel through some medium," which is often "an electrical connection, such as a wire." *Id.* (citing Ex. 1003 ¶ 172).

CyWee does not contest ZTE's arguments regarding claim 5, other than to argue in general that ZTE has failed to show that the Yamashita–Bachmann combination discloses all the elements of parent claim 1 and "discloses all elements of any claims depending from Claim 1." PO Resp. 34.

We find ZTE's arguments persuasive. Thus, we conclude that claim 5 is unpatentable under § 103 as obvious over Yamashita in light of Bachmann.

(n) Claims 14 and 19

We discuss claims 14 and 19 together because they are essentially identical. *Compare* Ex. 1001, 21:8–45, *with id.* at 22:17–54. The claims are similar to claim 1, except that they recite a method, rather than a device, but the method in claims 14 and 19 is essentially the same as the functional limitations of claim 1. *Compare* Ex. 1001, 21:8–45, *and id.* at 22:17–54, *with id.* at 18:54–19:26.

In challenging claims 14 and 19, ZTE relies largely on its analysis of claim 1, which we have addressed above. *See* Pet. 61–58. In response, CyWee contends that ZTE's analysis is "wholly insufficient," for four reasons that we discuss below. PO Resp. 35.

First, CyWee argues that ZTE "has not identified which quaternions in the combination of *Yamashita* and *Bachmann* are the 'second quaternion' recited by claims 14/19." PO Resp. 35.

We agree with CyWee that ZTE did not specify which quaternion was the "second quaternion" in its Petition. However, ZTE's Reply clarifies that in Bachmann's Figure 3, the angular velocities are converted to rate quaternion $\dot{q}$, which is then corrected by correction factor $\dot{q}_\varepsilon$ to obtain corrected rate quaternion $\dot{\tilde{q}}$. ZTE Reply 24 (citing Ex. 1030 ¶ 102). Thus, we understand ZTE to be arguing that rate quaternion $\dot{q}$ is the "second quaternion" representing the "current state." CyWee does not contest ZTE's arguments in its Sur-reply. *See* PO Sur-reply 15–19; Ex. 2015 ¶¶ 17–19.

We find ZTE's explanation in its Reply to be persuasive. According to claims 14 and 19, the "second quaternion" is "said current state of the six-axis motion sensor module . . . with respect to said current time T." Ex. 1001, 21:31–33, 22:40–42. The "current state," in turn, is obtained "by

obtaining measured angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the six-axis motion sensor module at a current time T." *Id.* at 21:19–22, 22:28–31. Bachmann discloses that rate quaternion $\dot{q}$ represents the angular velocities measured in the sensor module at the current time. *See* Ex. 1007, 9:59–60, 10:17–45, 11:17–20, Fig. 3. Rate quaternion $\dot{q}$ is then compared with the measured and a predicted axial accelerations ($\bar{y}_0$ and $\bar{y}(\hat{q})$, respectively) at the current time, through correction factor $\dot{q}_\varepsilon$. Thus, we agree with ZTE that rate quaternion $\dot{q}$ corresponds to the "second quaternion" recited in claims 14 and 19.

Second, CyWee challenges ZTE's argument that the Yamashita–Bachmann combination teaches "a three-dimensional (3D) pointing device utilizing a six-axis motion sensor module therein" as recited in the preambles of claims 14 and 19. PO Resp. 36 (citing Ex. 2001 ¶¶ 102–105). According to CyWee, Yamashita's gyroscopes are in a detachable gyrosensor unit with its own microcontroller, which teaches away from providing both a rotational sensor and an accelerometer in the same pointing device. *Id.* at 36–37 (citing Ex. 1006, 10:38–50, 54–61, 11:14–17, 14:28–34; Ex. 2001 ¶¶ 61–62, 103). CyWee also argues that Bachmann does not disclose a 3D pointing device at all, and that the individual components of Bachmann's MARG sensor "can be integrated using a single integrated circuit board with the accelerometers mounted separately," so Bachmann does not teach providing a 3D pointing device utilizing a six-axis motion sensor module therein. *Id.* at 37 (quoting Ex. 1007, 14:49–51) (citing Ex. 2001 ¶¶ 64–69).

We address CyWee's arguments above, in the context of limitations 1(c)–(d), and find them unpersuasive. *See supra* part IV.C.5(d).

Third, CyWee challenges ZTE's argument that the Yamashita–Bachmann combination teaches limitations 14(c) or 19(c). This limitation recites

> obtaining a measured state of the six-axis motion sensor module by obtaining measured axial accelerations Ax, Ay, Az gained from the motion sensor signals of the six-axis motion sensor module at the current time T and calculating predicted axial accelerations Ax′, Ay′, Az′ based on the measured angular velocities ω_x, ω_y, ω_z of the current state of the six-axis motion sensor module without using any derivatives of the measured angular velocities ω_x, ω_y, ω_z.

Ex. 1001, 21:23–31, 22:32–40. CyWee reiterates its arguments with respect to limitation 1(n), which we address above and find unpersuasive because Bachmann teaches a measured state that includes measured axial accelerations $\bar{y}_0$ (box 34 in Figure 3) and predicted axial accelerations $\bar{y}(\hat{q})$ (box 35a in Figure 3). *See supra* part IV.C.5(k).

Finally, CyWee challenges ZTE's argument that the Yamashita–Bachmann combination teaches limitation 14(f) or 19(f). This limitation recites "obtaining an updated state of the six-axis motion sensor module by comparing the current state with the measured state of the six-axis motion sensor module." Ex. 1001, 21:39–41, 22:48–50. CyWee alleges that "[t]he '438 Patent claims an update program that utilizes elements of an Extended Kalman Filter estimator (EKF)." PO Resp. 40–41 (citing Ex. 1001, 13:51–14:22; Ex. 2015 ¶ 14). According to CyWee, "[i]t would be readily apparent to a [person of ordinary skill in the art] that an iterative process such as the Gauss-Newton minimization that *Bachmann* discloses is fundamentally different from a process that utilizes elements of an EKF." *Id.* at 41.

CyWee also made this argument with respect to limitation 1(m), and we likewise find the argument unpersuasive as to claims 14 and 19. *See supra* part IV.C.5(j). Like claim 1, claims 14 and 19 do not include any limitation requiring the use of an extended Kalman filter.

For all the above reasons, including our analysis above with respect to similar claim 1, we find that a person of ordinary skill in the art would have been motivated to combine the teachings of the references to obtain a method as recited in claims 14 and 19, including all their limitations. Therefore, we conclude that claims 14 and 19 are unpatentable under § 103 as obvious over Yamashita in light of Bachmann.

(o) Claim 15

Claim 15 depends from claim 14 and "further comprises the step of outputting the updated state of the six-axis motion sensor module to the previous state of the six-axis motion sensor module." Ex. 1001, 21:48–50.

In the Petition, ZTE relies on its arguments for limitations 1(j) and 1(m). Pet. 58. ZTE's argument for limitation 1(m) contends that in Bachmann, each successive "updated state" is calculated in part from the "previous state" (the updated state from the previous time interval) according to Equation 16. Pet. 50–51.

Claim 15 also includes a limitation that "said resultant angles of the resulting deviation include[] yaw, pitch and roll angles about each of three orthogonal coordinate axes of the spatial pointer reference frame." Ex. 1001, 21:50–53. ZTE argues that "Yamashita disclose[s] the use of yaw, pitch, and roll angles," as ZTE argued with respect to limitation 1(i). Pet. 58 (citing Pet. 48).

CyWee does not contest ZTE's arguments regarding claim 15, other than to argue in general that ZTE has failed to show that the Yamashita–Bachmann combination discloses all the elements of parent claim 14 and "discloses all elements of any claims depending from Claim 14." PO Resp. 41–42.

We find ZTE's arguments persuasive, so we conclude that claim 15 is unpatentable under § 103 as obvious over Yamashita in light of Bachmann.

(p) Claim 16

Claim 16 depends from claim 14 and recites "wherein said previous state of the six-axis motion sensor module is a first quaternion with respect to said previous time $T-1$; and said updated state of the six-axis motion sensor module is a third quaternion with respect to said current time T." Ex. 1001, 21:54–22:4. In the Petition, ZTE relies on its arguments as to limitations 1(i), 1(j), and 1(m). Pet. 59.

In response, CyWee argues that ZTE "has not identified which quaternions in the combination of *Yamashita* and *Bachmann* are the . . . 'first quaternion' or 'third quaternion' recited by claim 16." PO Resp. 35.

In its Reply, ZTE argues that the "first quaternion," representing the "previous state," is the output $\hat{q}$ at the previous time step, which is then used to form a correction factor at the next time step to calculate the "third quaternion," representing the "updated state" at the current time step. *See* ZTE Reply 24.

CyWee does not contest ZTE's assertion in its Sur-reply. *See* PO Sur-reply 15–19; Ex. 2015 ¶¶ 17–19. We find ZTE's arguments persuasive, and therefore conclude that claim 16 is unpatentable under § 103 as obvious over Yamashita in light of Bachmann.

(q) Claim 17

Claim 17 depends from claim 14, and recites "wherein the obtaining of said previous state of the six-axis motion sensor module further comprises initializing said initial-value set." Ex. 1001, 22:6–8. ZTE relies on its arguments for limitations 1(m)–(n), and also argues that Yamashita discloses an "initial-value set." Pet. 59–60 (citing Ex. 1006, 22:59–23:26, Fig. 26).

CyWee does not contest ZTE's assertion in its Sur-reply. *See* PO Sur-reply 15–19; Ex. 2015 ¶¶ 17–19. We find ZTE's arguments persuasive, and therefore conclude that claim 17 is unpatentable under § 103 as obvious over Yamashita in light of Bachmann.

6. Conclusion

Based on the evidence and arguments of record, we determine that ZTE has shown, by a preponderance of the evidence, that claims 1, 4, 5, 14–17, or 19 of the '438 patent would have been obvious over Yamashita in view of Bachmann, and are thus unpatentable.

D. GROUND BASED ON NASIRI AND SONG

ZTE's second ground in the Petition is that claims 1, 4, 5, 14–17, and 19 of the '438 patent would have been obvious over Nasiri (which incorporates Sachs by reference) in view of Song. Pet. 6. We find that ZTE has not shown that the challenged claims are unpatentable on this ground, for the reasons discussed below.

1. Overview of Nasiri, Sachs, and Song

Nasiri discloses "systems and methods capable of facilitating interaction with handheld electronic[] devices based on sensing rotational

rate around at least three axes and linear acceleration along at least three axes." Ex. 1008, code (57). It incorporates Sachs by reference in its entirety, including its "algorithm combining inputs from multiple sensors to provide more robust sensing." *Id.*, 14:53–57.

The algorithm that Nasiri incorporates from Sachs "combin[es] gyroscope and accelerometer data to produce a model of the orientation of the device using world coordinates." Ex. 1009 ¶ 68. It uses quaternions to represent orientation, and updates the quaternions using corrections derived ultimately from raw accelerometer and gyroscope data. *See id.* ¶¶ 69–74.

Song discloses "a method and apparatus for recognizing space according to the movement of an input device . . . using an angular velocity sensor and an accelerometer." Ex. 1010 ¶ 3. Part of the relevant apparatus includes a transmitter that wirelessly transmits position information from an input device (such as a mouse or remote control) to a receiver. *Id.* ¶ 3.

2. Alleged Obviousness Rationale Based on Nasiri and Song

ZTE alleges that a person of ordinary skill in the art would have had reason to combine Nasiri's sensor module and application processor with Song's wireless interface, in order to "physically separate the sensor module from the application processor in order to reduce the size[,] weight and power consumption of the handheld unit." Pet. 31.

CyWee does not specifically challenge ZTE's rationale for combining Nasiri with Song, and we find that rationale persuasive.

3. Comparison of the Challenged Claims with Nasiri, Sachs, and Song.

The Petition includes a limitation-by-limitation analysis purportedly comparing the challenged claims with Nasiri, Sachs, and Song. Pet. 31–60. However, we find that ZTE has not met its burden to identify, "with particularity, . . . the grounds on which the challenge to each claim is based, and the evidence that supports the grounds for the challenge to each claim." 35 U.S.C. § 322(a)(3); *see also* 37 C.F.R. §§ 42.22(a)(2), 42.204(b)(4); *Magnum Oil Tools*, 829 F.3d at 1380 (A petition must "articulate specific reasoning, based on evidence of record, to support the legal conclusion of obviousness." (citing *KSR*, 550 U.S. at 418)).

With regard to claims 1, 4, and 5, CyWee only disputes ZTE's argument that Nasiri (including by incorporation Sachs) discloses limitations 1(l)–(n) of claim 1. *See* PO Resp. 49–54.

Limitations 1(l) and 1(m), taken together, recite "wherein the comparison utilized by the processing and transmitting module further comprises an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set." Ex. 1001, 19:18–23. According to ZTE, Sachs discloses an update program that updates quaternion q', representing the orientation of a device, according to the following equation:

$$q' = \text{normalize}(q + q_{accelerometer} + q_{gyroscope})$$

where q is the current quaternion (i.e., the current state), $q_{accelerometer}$ is a quaternion update term based on the current quaternion and measured accelerometer data, and $q_{gyroscope} = 0.5qw(dt)$ is another update term in

which q is the current quaternion, w is the raw gyroscope data, and dt is the sample time of the sensor data. Pet. 76–78 (citing Ex. 1009 ¶¶ 69–73).

According to ZTE, Sachs "disclose[s that] the updated state is based on a previous state associated with said first signal set (angular velocities), $q_{gyroscope}$." Pet. 76. Although ZTE does not explicitly say why $q_{gyroscope}$, is associated with a *previous* state associated with angular velocities, we note that the formula for $q_{gyroscope}$ depends on current quaternion q, which was calculated using gyroscope data in the previous iteration. ZTE also appears to identify $q_{accelerometer}$ as the "measured state associated with said second signal set." *See* Pet. 77–78 (citing Ex. 1009 ¶ 69–71).

CyWee contends that Sachs does not disclose limitation 1(m) because the cited passages in Sachs "do not make use of any part of the enhanced comparison method claimed by the '438 Patent," and in particular, "*Sachs* does not make use of anything remotely similar to the enhanced comparison method described in equations 5–11." PO Resp. 52 (citing Ex. 2001 ¶ 114–115). We do not find this argument persuasive, because limitation 1(m) does not require the use of equations 5–11 found in the '438 patent specification. *See Hiniker*, 150 F.3d at 1368–69 (characteristics found in the written description, but not in the claims, are not considered in an obviousness analysis).

Limitation 1(n) recites "wherein the measured state includes a measurement of said second signal set and a predicted measurement obtained based on the first signal set without using any derivatives of the first signal set." Ex. 1001, 19:23–26.

ZTE argues that the measured state in Sachs includes a "measurement of said second signal set" because Sachs "discloses accelerometers [and]

generates acceleration data as part of the augmented data for [the] device." Pet. 78 (citing Ex. 1009 ¶ 62, Fig. 7). Thus, ZTE identifies the recited "measurement" as the processed accelerometer data. ZTE also argues that Sachs discloses a "predicted measurement obtained based on the first signal set without using any derivatives of the first signal set" because "[w]hen the processing is done in a discrete time system, the time increment is known and fixed," and the device "computes the changes directly using only delta rotations, not rotation rates." Pet. 79 (citing Ex. 1003 ¶ 233).

However, ZTE does not specifically identify the "predicted measurement" in Sachs, explain why it is a prediction, or explain why the recited "measured state" (which ZTE appears to identify as $q_{accelerometer}$ in limitation 1(m)) includes both a measurement and a prediction. Thus, we find that ZTE's analysis of limitation 1(n) is insufficiently specific to show, by a preponderance of the evidence, that claim 1 would have been obvious over Nasiri and Sachs in view of Song. ZTE's analysis for dependent claims 4 and 5, which focuses only on the added limitations of those claims, does not cure this deficiency. *See* Pet. 80–83.

ZTE's limitation-by-limitation analysis of claims 14–17 and 19 is likewise insufficiently specific, because ZTE's analysis for each limitation simply refers back to its analysis for claim 1. *See* Pet. 83–88. ZTE also does not identify the features of these claims that are not specifically present in claim 1. For example, ZTE's analysis does not identify which quaternion disclosed in Sachs is the "second quaternion" recited in claims 14 and 19, or the "first quaternion" or "third quaternion" recited in claim 16. Ex. 1001, 21:32, 22:1, 3, 41.

4. Conclusion

Based on the evidence and arguments of record, ZTE has not shown, by a preponderance of the evidence, that claims 1, 4, 5, 14–17, or 19 of the '438 patent are unpatentable as obvious over Nasiri in view of Song.

V. CYWEE'S REVISED MOTION TO AMEND

Because we conclude that all of the challenged claims are unpatentable based on ground 1 of the Petition, we consider CyWee's Revised Motion to Amend. *See* RMTA (Paper 38) 1 (stating that the Revised Motion to Amend is "contingent upon a finding that the original challenged claims of [the '438 patent] are invalid"). For the reasons below, we find that proposed substitute claims 21 and 24 introduce new subject matter and we conclude that all the proposed substitute claims are unpatentable under § 103. Therefore, we deny the Revised Motion to Amend.

A. PROPOSED SUBSTITUTE CLAIMS

CyWee proposes claim 20 as a substitute for claim 1, claim 21 as a substitute for claim 5, claim 22 as a substitute for claim 14, claim 23 as a substitute for claim 15, and claim 24 as a substitute for claim 19. RMTA App'x 1–5.

The proposed substitute claims are reproduced below, using underlining to indicate text added to the original claims and bracketed strikethrough to indicate text removed from the original claims:

[20(pre)] 20. A three-dimensional (3D) pointing device, which is handheld, subject to movements and rotations in dynamic environments, comprising:

[20(a)] a single housing associated with said movements and rotations of the 3D pointing device in a spatial pointer reference frame;

[20(b)] a single printed circuit board (PCB) enclosed by the housing;

[20(c)] a six-axis motion sensor module attached to the PCB, comprising a rotation sensor for detecting and generating a first signal set comprising angular velocities ω_x, ω_y, ω_z associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame,

[20(d)] an accelerometer for detecting and generating a second signal set comprising axial accelerations Ax, Ay, Az associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame;

[20(e)] ~~[and]~~ a processing and transmitting module, comprising a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting said first and second signal sets thereof and a computing processor for receiving and calculating said first and second signal sets from the data transmitting unit,

[20(f)] communicating with the six-axis motion sensor module to calculate a resulting deviation comprising resultant angles in said spatial pointer reference frame

[20(g)] by utilizing a comparison to compare the first signal set with the second signal set whereby said resultant angles in the spatial pointer reference frame of the resulting deviation of the six-axis motion sensor module of the 3D pointing device are obtained under said dynamic environments,

wherein the comparison utilized by the processing and transmitting module further comprises an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set;

[20(h)] wherein the measured state includes a measurement of said axial accelerations of said second signal set and a predicted measurement of said axial accelerations of said second signal set obtained based on the first signal set without using any derivatives of the first signal set[.]; and

[20(i)] a display device built-in to and integrated with the 3D pointing device and associated with a display reference frame, wherein said resultant angles of the resulting deviation in the spatial pointer reference frame are translated to a movement pattern in the display reference frame.

[21] The 3D pointing device of claim 1, wherein the 3D pointing device is a cellular phone, and wherein the PCB enclosed by the housing comprises at least one substrate having a first longitudinal side configured to be substantially parallel to a longitudinal surface of the housing.

[22(Pre)] 22. A method for obtaining a resulting deviation including resultant angles in a spatial pointer reference frame of a three-dimensional (3D) pointing device utilizing a six-axis motion sensor module attached to a single PCB therein and subject to movements and rotations in dynamic environments in said spatial pointer reference frame, wherein the 3D pointing device comprises a single housing unit and a display device built-in to and integrated with the 3D pointing device and associated with a display reference frame, comprising the steps of:

[22(a)] obtaining a previous state of the six-axis motion sensor module; wherein the previous state includes an

initial-value set associated with previous angular velocities gained from the motion sensor signals of the six-axis motion sensor module at a previous time T−1;

[22(b)] obtaining a current state of the six-axis motion sensor module by obtaining measured angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the six-axis motion sensor module at a current time T;

[22(c)] obtaining a measured state of the six-axis motion sensor module by obtaining measured axial accelerations Ax, Ay, Az gained from the motion sensor signals of the six-axis motion sensor module at the current time T and calculating predicted axial accelerations Ax′, Ay′, Az′ based on the measured angular velocities ω_x, ω_y, ω_z of the current state of the six-axis motion sensor module without using any derivatives of the measured angular velocities ω_x, ω_y, ω_z;

[22(d)] said current state of the six-axis motion sensor module is a second quaternion with respect to said current time T;

[22(e)] comparing the second quaternion in relation to the measured angular velocities ω_x, ω_y, ω_z of the current state at current time T with the measured axial accelerations Ax, Ay, Az and the predicted axial accelerations Ax′, Ay′, Az′ also at current time T;

[22(f)] obtaining an updated state of the six-axis motion sensor module by comparing the current state with the measured state of the six-axis motion sensor module; ~~[and]~~

[22(g)] calculating and converting the updated state of the six axis motion sensor module to said resulting deviation comprising said resultant angles in said

spatial pointer reference frame of the 3D pointing device.

[23] 23. The method for obtaining a resulting deviation of a 3D pointing device of claim 14, further comprises the step of outputting the updated state of the six-axis motion sensor module to the previous state of the six-axis motion sensor module; and wherein said resultant angles of the resulting deviation includes yaw, pitch and roll angles about each of three orthogonal coordinate axes of the spatial pointer reference frame and said angular velocities ω_x, ω_y, ω_z and said second quaternion are represented by at least one Extended Kalman Filter equation; and the step of using at least one Jacobian to linearize said measured state.

[24(Pre)] 24. A method utilizing at least one Extended Kalman Filter equation for obtaining a resulting deviation including resultant angles in a spatial pointer reference frame of a three-dimensional (3D) pointing device utilizing a six-axis motion sensor module attached to a single PCB therein and subject to movements and rotations in dynamic environments in said spatial pointer reference frame, wherein the 3D pointing device comprises a cellular phone with a display device built-in to and integrated with the 3D pointing device and associated with a display reference frame, comprising the steps of:

[24(a)] obtaining a previous state of the six-axis motion sensor module; wherein the previous state includes an initial-value set associated with previous angular velocities gained from the motion sensor signals of the six-axis motion sensor module at a previous time T−1;

[24(b)] obtaining a current state of the six-axis motion sensor module by obtaining measured angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the six-axis motion sensor module at a current time T;

[24(c)] obtaining a measured state of the six-axis motion sensor module by obtaining measured axial accelerations Ax, Ay, Az gained from the motion sensor signals of the six-axis motion sensor module at the current time T and calculating predicted axial accelerations Ax′, Ay′, Az′ based on the measured angular velocities ω_x, ω_y, ω_z of the current state of the six-axis motion sensor module without using any derivatives of the measured angular velocities ω_x, ω_y, ω_z;

[24(d)] said current state of the six-axis motion sensor module is a second quaternion with respect to said current time T; said measured angular velocities ω_x, ω_y, ω_z and said second quaternion are represented by at least one Extended Kalman Filter equation; and at least one Jacobian is used to linearize said measured state;

[24(e)] comparing the second quaternion in relation to the measured angular velocities ω_x, ω_y, ω_z of the current state at current time T with the measured axial accelerations Ax, Ay, Az and the predicted axial accelerations Ax′, Ay′, Az′ also at current time T;

[24(f)] obtaining an updated state of the six-axis motion sensor module by comparing the current state with the measured state of the six-axis motion sensor module; [~~and~~]

[24(g)] calculating and converting the updated state of the six axis motion sensor module to said resulting deviation comprising said resultant angles in said spatial pointer reference frame of the 3D pointing device[~~.~~]; and

[24(h)] translating said resultant angles of the resulting deviation to a movement pattern in the display reference frame.

RMTA App'x 1–5 (claim numbers added, and formatting added for consistency and to match the original claims).

CyWee states that the proposed amendments in substitute claim 20 are (1) "to clarify that the 3D pointing device is handheld"; (2) to clarify "that the 'measured state' includes both the measurement and predicted measurement of the axial accelerations of the second signal set"; (3) "to limit the embodiments to those with the sensor module attached to a single PCB and contained within a single housing," and (4) "to limit the claimed device to a 3D pointing device with an integrated display screen." RMTA 1. CyWee intends proposed substitute claim 21, which depends from claim 1, to "further limit the 3D pointing device . . . to a cellular phone device." *Id.* at 19.

CyWee also states that proposed substitute claim 22 "clarifies that the 3D pointing device used in the method is handheld, limits the embodiments to those with the sensor module attached to a single PCB within a single housing, and limits the claimed method to a 3D pointing device with an integrated display screen"; proposed substitute claim 23 "clarifies that the angular velocities and the second quaternion are represented by an Extended Kalman Filter ('EKF')"; and proposed substitute claim 24 "contains all of the clarifications and limitations of the preceding Proposed Contingent Claims." *Id.* at 1–2.

B. PRELIMINARY MATTERS

Before addressing the merits of CyWee's Revised Motion to Amend, we consider three threshold matters: (1) the question of whether LGE may raise new arguments in its Opposition to the Revised Motion to Amend that

ZTE did not previously raise; (2) CyWee's motion to exclude certain exhibits relating to LGE's Opposition, and (3) objections by CyWee and LGE to the demonstrative exhibits used in the oral hearing. We address these issues in turn.

1. Whether LGE May Raise New Arguments That ZTE Did Not Previously Raise

When we joined LGE to this proceeding under 35 U.S.C. § 315(c), we noted that LGE had agreed to act in a passive "understudy" role and would not assume an active role unless ZTE ceased to participate in the *inter partes* review. Paper 36, 46. After ZTE declined to oppose CyWee's Revised Motion to Amend, we allowed LGE to "present arguments and evidence, independently from ZTE, in response to CyWee's Revised Motion to Amend," which were "limited solely to the issues raised in CyWee's Revised Motion to Amend." Paper 50, 9.

LGE's Opposition to the Revised Motion to Amend made some arguments that ZTE could have made in its Opposition to the Motion to Amend. These new arguments included the following: (1) that CyWee has failed to meet its burden with respect to its revised motion to amend by failing to adequately address whether there is written description support for the proposed substitute claims *as a whole* (Opp. RMTA, 1–3); (2) that limitation 20(i) introduces a process step that makes apparatus claims 20 and 21 indefinite (*id.* at 6–7); (3) that the '438 patent disclosure does not adequately support predicting axial limitations without using any derivatives of the measured angular velocities as recited in limitations 20(h), 22(c), or 24(c) (*id.* at 8–9); (4) that the '438 patent disclosure does not adequately enable certain aspects of limitations 20(g), 20(h), 22(c), 22(e)–(g), 24(c), or

24(e)–(g) (*id.* at 9–15); (5) that CyWee is estopped under 37 C.F.R. § 42.73 from making the proposed amendments (*id.* at 15); and (6) that the proposed substitute claims are ineligible subject matter under 35 U.S.C. § 101 (*id.* at 24–25).[34]

In briefing that we authorized after the oral hearing, CyWee argued that, in general, replies and sur-replies are limited to arguments raised in the preceding brief, so by analogy, the same limitation should apply to arguments made in opposition to a revised motion to amend. Paper 82, 1–2 (citing CTPG 72–74). CyWee contends that "[i]t would be counterintuitive to allow the RMTA opposition to re-open an unrestricted universe of issues and arguments never addressed in response to the original MTA when the RMTA itself is limited to 'the preliminary guidance or the petitioner's opposition.'" *Id.* at 2 (citing CTPG 73).

CyWee also noted that we had limited LGE's participation in the proceeding "solely to the issues raised in CyWee's Revised Motion to Amend." *Id.* (emphasis omitted) (quoting Paper 50, 9). According to CyWee, "[a]ny issue that could have been raised previously, *i.e.*, before the RMTA, including [the four issues listed above in this decision] is, by definition, not an issue limited to the RMTA." *Id.* CyWee contends that "[a] contrary rule would invite a lead petitioner to drop out only to give a joined petitioner another 'bite' at the 'motion to amend apple' after the preliminary guidance rejected its first wave of attacks." *Id.* CyWee argues that this concern is

[34] Before the oral hearing, CyWee specifically raised the issue of whether LGE should be precluded as to issues 1 and 6. *See* Reply RMTA 3, 24–25. LGE responded on the preclusion issue as to issue 6. *See* Sur-reply RMTA 11.

particularly significant given that LGE would have been time barred if not for being joined to this case. *See id.* at 3–5.

LGE argues that there is no explicit limitation in the Board's rules or orders that would limit the scope of arguments LGE can raise in its Opposition to the Revised Motion to Amend. Paper 83, 1–3. According to LGE, the public interest is best served by allowing LGE to oppose the Revised Motion to Amend in a meaningfully adversarial way, including by raising arguments that ZTE had insufficiently developed, as an alternative to the disfavored option in which the Board raises such issues *sua sponte*. *Id.* at 3 (citing *Hunting Titan, Inc. v. DynaEnergetics Europe GmbH*, IPR2018-00600, Paper 67 at 25 (PTAB July 6, 2020) (precedential)). LGE contends that this is consistent with the rationale by which we allowed LGE to step into the role of lead petitioner with respect to the Revised Motion to Amend. *See id.* at 3–4.

LGE also argues that in deciding the Revised Motion to Amend, we must consider the record as a whole, including any new arguments that LGE has raised on the record. *Id.* at 5 (citing *Nike, Inc. v. Adidas AG*, 955 F.3d 45, 51 (Fed. Cir. 2020) ("[T]he Board must consider the *entirety* of the record before it when assessing the patentability of amended claims.")).

Under the circumstance of this case, we need not decide whether LGE's new arguments, made for the first time in its Opposition, are improper, because they are not determinative of our decision. *See Boston Scientific Scimed, Inc. v. Cook Group Inc.*, 809 F. App'x 984, 990 (Fed. Cir. 2020) (holding that once a petitioner has prevailed on all its challenged claims, "the Board need not address issues that are not necessary to the resolution of the proceeding"); *Beloit Corp. v. Valmet Oy*, 742 F.2d 1421,

1423 (Fed. Cir. 1984) (holding that once a dispositive issue is decided, there is no need to decide other potentially dispositive issues). As discussed below, we conclude that proposed substitute claims 20–24 are unpatentable under § 103, and find that proposed substitute claims 21 and 24 introduce new matter by adding the term "cellular phone." While we do not address the substance of LGE's new arguments in the decision below, this neither reflects a determination for or against the propriety of LGE's new arguments.

2. CyWee's Motion to Exclude

CyWee moves to exclude Exhibits 1046–1058, which LGE submitted to support its Opposition to CyWee's Revised Motion to Amend. Paper 66 1–2 ("Mot. Exclude). LGE filed an Opposition to this Motion (Paper 69, "Opp. Mot. Exclude"), and CyWee filed a Reply (Paper 73, "Reply Mot. Exclude"). CyWee raises two grounds for excluding the exhibits, which we address below.

(a) Objection Under Fed. R. Evid. 403

First, "CyWee objects to [Exhibits 1046–1058] as unfairly prejudicial under Fed. R. Evid. 403" because they were "submitted solely by LG[E], and not the original petitioner ZTE." Mot. Exclude 2, 4–5. CyWee states that it made its objections to this evidence in its Request for Reconsideration (Paper 52) of our Decision (Paper 50) in which we allowed LGE to step into the role of lead petitioner in opposing the Revised Motion to Amend. *Id.* at 2. CyWee says that it also objected to LGE's participation in the oral hearing

(Paper 61). *Id.* For its Motion to Exclude, CyWee relies on the arguments it made in its Request for Reconsideration. *See* Mot. Exclude 4–5.[35]

LGE argues that CyWee's objections were untimely because, under 37 C.F.R. § 42.64(b)(1), "[o]nce a trial has been instituted, any objection must be **filed within five business days of service of evidence** to which the objection is directed.'" Reply Mot. Exclude 1 (alteration in original). According to LGE, it filed and served the contested exhibits on September 30, 2020, but CyWee did not object until October 21 (PO Reply RMTA, Paper 65) or October 23 (the Motion to Exclude). *Id.* at 1–2. LGE also contends that CyWee did not identify any grounds for its objections with "s[ufficient] particularity to allow correction in the form of supplemental evidence." *Id.* at 8 (quoting 37 C.F.R. § 42.64(b)(1)).

In response to LGE's timeliness challenge, CyWee contends that the objections were timely because LGE and the Board were aware of its generalized objection before LGE submitted the challenged exhibits. *See* Reply Mot. Exclude 2.

We agree that CyWee apprised the Board of its opposition to LGE's participation in the remainder of the trial prior to LGE's submission of the challenged exhibits. But CyWee's reliance on its generalized objection to LGE's participation in the trial is insufficient to comply with the regulation, particularly after the Board's ruling that allowed LGE's participation. CyWee did not make any specific objection alleging that the contents of LGE's exhibits were inadmissible under Rule 403 of the Federal Rules of

[35] Our reasons for denying CyWee's Request for Reconsideration are set forth in our Decision denying the Request. Paper 71. We need not repeat those reasons here.

Evidence until it filed its Motion to Exclude. Thus, we find that CyWee did not make a timely objection to the challenged exhibits that "identif[ies] the grounds for the objection with sufficient particularity to allow correction in the form of supplemental evidence." 37 C.F.R. § 42.64(b)(1).

Also, even if CyWee had made timely objections, its Motion to Exclude does not clearly explain why LGE's exhibits are unfairly prejudicial under Rule 403, independent of CyWee's generalized objection to LGE's active participation in the trial. That generalized objection is insufficient in light of the Board's ruling allowing LGE's active participation.

Rule 403 states that we "may exclude relevant evidence if its probative value is substantially outweighed by a danger of . . . unfair prejudice." Fed. R. Evid. 403. However, CyWee does not discuss the probative value of the exhibits[36] or the nature of the alleged unfair prejudice as it relates to the contents of those exhibits. The only unfair prejudice CyWee raises is a generalized prejudice that CyWee believes it has suffered by our decision to allow LGE to oppose its Revised Motion to Amend. However, CyWee does not tie this alleged prejudice to the specific contents of the contested exhibits.

Exhibits 1046–1058, as a whole, are highly probative to the issues raised in CyWee's Revised Motion to Amend. They include, among other things, Professor LaViola's second deposition transcript (Ex. 1048), the asserted prior art references (Exs. 1049, 1050), and the declaration of LGE's

[36] CyWee contends that since LGE should not be allowed to submit evidence opposing the Revised Motion to Amend, "LG[E]'s proffered evidence therefore has no probative value." But whether LGE should be allowed to submit evidence is a different question than whether the proffered evidence has probative value.

expert Professor Michalson (Ex. 1051). Given their probative nature, and the lack of specific evidence of unfair prejudice tied to contents of the exhibits themselves, we find that CyWee has not set forth a valid reason to exclude the exhibits under Rule 403.

(b) Objection to Exhibits 1047 and 1048 Under Fed. R. Evid. 401

CyWee separately objects to Exhibits 1047 and 1048 under Fed. R. Evid. 401 and 403 on the ground that the exhibits are irrelevant and "merely duplicative, unfairly prejudicial and merely confuse the issues." Mot. Exclude 2–3; *see also id.* at 5–7. Exhibit 1047 is a copy of the '438 patent with markup that Professor LaViola added during his second deposition, dated September 18, 2020. *See id.* at 5. Exhibit 1048 is the transcript of that deposition. Ex. 1048, 1. Specifically, CyWee challenges LGE's use of the transcript regarding

> (1) support for claim limitations that are unchanged since the Board's Preliminary Guidance ([Opp. RMTA] 2), (2) a [person of ordinary skill in the art]'s understanding of the equations disclosed in the '438 patent (*id.* at 8–14), (3) a purported comparison of other amended claims from a different IPR brought by a different party (*id.* at 15), and (4) an assertion that the '438 patent is directed to patent ineligible subject matter (*id.* at 24–25).

Mot. Exclude 5.

First, we address the matter of timing. CyWee states that it filed objections to these exhibits on September 23, 2020. *Id.* at 3 (citing Paper 59). LGE contends that CyWee did not object to the contents of Exhibit 1047, or to the challenged deposition contents, at Professor LaViola's deposition itself, contrary to 37 C.F.R. § 42.64(a). Opp. Mot. Exclude 4–5

(citing Ex. 1048, 128:2–20 (introducing a version of Ex. 1047 without objection from CyWee's counsel)).

We agree with LGE that CyWee's objections were untimely. "An objection to the admissibility of deposition evidence must be made during the deposition." 37 C.F.R. § 42.64(a). The purpose of this rule is so that the opposing party may submit "[e]vidence to cure the objection . . . during the deposition." *Id.* Waiting until after the deposition deprives the opposing party of that opportunity.

Even if we were to consider CyWee's objections timely, we would find CyWee's arguments for excluding Exhibits 1047 and 1048 unpersuasive. We address these arguments below.

First, CyWee contends that Professor LaViola's second deposition transcript and the marked-up '438 patent concern "claim limitations that are unchanged since the Board's Preliminary Guidance." Mot. Exclude 5 (citing Opp. RMTA, 2). According to CyWee, when ZTE originally deposed Professor LaViola in 2019, prior to ZTE's Reply to the Patent Owner Response, Professor LaViola testified about "a [person of ordinary skill in the art]'s understanding of the '438 patent specification, including the equations recited therein and disclosure of elements of Kalman and extended Kalman filters." *Id.* (citing Ex. 1028, 20–42). CyWee contends that the annotations on Exhibit 1047 focus on these same equations. *Id.* Thus, according to CyWee, this testimony is "merely duplicative of evidence that has already been of record and considered for issues that have been decided," and is thus "not relevant to any issue that remains to be decided." *Id.* at 6. CyWee also argues that "[c]onsideration of the evidence will . . . merely infuse needless confusion and unfair prejudice." *Id.*

LGE responds that Exhibits 1047 and 1048 are not duplicative of any "issues that have been decided" because in this proceeding, no issues have yet been decided on the merits. Opp. Mot. Exclude 12. LGE also states that, "[i]n any event, expert testimony related to the issues raised in the expert's declaration is highly relevant." *Id.*

We agree with LGE. At the time of Professor LaViola's first deposition in 2019, CyWee had not filed its Revised Motion to Amend in which it introduced limitations requiring the use of "at least one Extended Kalman Filter equation." RMTA App'x 3–4.[37] Thus, LGE's questioning on that issue, and Professor LaViola's markup of these equations on a copy of the '438 patent, are highly probative to whether these new limitations find support in the '438 patent or would have been obvious in view of the prior art—both of which are new issues raised by CyWee's Revised Motion to Amend.

Second, CyWee argues that LGE uses Exhibit 1048 to show "a [person of ordinary skill in the art]'s understanding of the equations disclosed in the '438 patent." Mot. Exclude 5 (citing Opp. RMTA, 8–14). According to CyWee, "[m]any of the issues regarding the adequacy of disclosure for which LG[E] cites Exhibit 1048 were previously decided and addressed in the Board's Preliminary Guidance," so the proffered evidence

---

[37] These new limitations are substantially different from corresponding limitations in proposed substitute claims 23 and 24 of the original Motion to Amend, which required using "elements of an Extended Kalman Filter." Paper 19 App'x, 3–4. The original version of proposed substitute claims 23 and 24 also omitted the later-added requirement of a "Jacobian to linearize said measured state." *See id.* In our Preliminary Guidance, we expressed our preliminary view that the original limitations of proposed substitute claims 23 and 24 were indefinite. *See* Paper 35, 10.

is "not relevant to any issue that remains to be decided," and considering that evidence would "merely infuse needless confusion and unfair prejudice." *Id.* at 6.

LGE counters that "the Board's Preliminary Guidance is just that—preliminary," so it is not a reflection of any resolved issues in the proceeding. Opp. Mot. Exclude 13 (citing Paper 34, 2–3 (stating that the Preliminary Guidance is preliminary and non-binding)).

We agree with LGE that our Preliminary Guidance did not reflect the resolution of any issues, and did not in itself preclude the submission of additional evidence, particularly on issues raised in the Revised Motion to Amend, such as evidence relating to the alleged extended Kalman filter equations and Jacobians in the '438 patent.

CyWee's third argument is that LGE uses Exhibit 1048 to show "a purported comparison of other amended claims from a different IPR brought by a different party." Mot. Exclude 5 (citing Opp. RMTA, 15); *see also id.* at 6–7 (citing Opp. RMTA 15). CyWee's fourth argument is that LGE uses the deposition transcript to show "an assertion that the '438 patent is directed to patent ineligible subject matter." Mot. Exclude 5 (citing Opp. RMTA, 24–25).

As we discuss above, our decision does not rely on the new issues that LGE raises in its Opposition to the Revised Motion to Amend that ZTE could have raised in opposition to the original Motion to Amend. CyWee's third and fourth arguments relate to two such issues (estoppel and patent eligibility under § 101). *See supra* part V.B.1. Thus, CyWee's third and fourth arguments are moot.

For the above reasons, we deny CyWee's Motion to Exclude Exhibits 1046–1058.

3. Objection to Demonstratives

CyWee and LGE each object to demonstratives used by the opposing side during the oral hearing. For the reasons below, we overrule those objections.

CyWee objects to slides 19, 22, 25, 33, 36–38, 42, 73, and 91–93 because they "contain excerpted testimony that omits objections to the testimony appearing in the transcript and/or omits additional surrounding testimony and evidence needed for a full and complete understanding of the testimony." Paper 80, 2. CyWee objects to slides 31, 29, 33, 39, 51–56, 66–68, 71, and 77–88 on the ground that "[t]he purported underlying evidence presented in these slides is presented as testimony of a qualified technical expert, but because LG[E]'s expert Dr. Michalson did not write his report, it is in fact merely attorney argument." *Id.* Finally, CyWee objects to slides 43, 47–48, and 90 on the ground that they are "merely duplicative of evidence already of record and/or go[] beyond the limited purpose pursuant to which LG[E] is entitled to participate as set forth in, *inter alia*, Papers 66 and 73." *Id.* at 2–3.

LGE objects to slides 13–15 as "contain[ing] brand new arguments not present in any briefs, and also cit[ing] to new cases not cited in the briefs." Paper 78, 2. LGE objects to slide 30 because the "[l]ast bullet point is a new argument not present in the briefs." *Id.* LGE objects to slide 44 because the phrase "In fact, it does not" is a new argument not present in the briefs. *Id.*

We have considered the objections. However, (1) the demonstratives are not submitted as evidence, (2) not all the challenged slides were actually used in the hearing, and (3) we are capable of properly weighing the material referenced in the demonstrativs based on its probative value. We also have access to the exhibits in the case, so we are able to see the full context of the quoted material, and we have taken that context into consideration in our decision.

Therefore, the objections by both CyWee and LGE are *overruled*.

C. CyWee's Burden to Show Compliance with Statutory and Regulatory Requirements

We next consider whether CyWee has met its burden to show that it has met the statutory and regulatory requirements for a motion to amend.

"Before considering the patentability of any substitute claims, . . . the Board first must determine whether the motion to amend meets the statutory and regulatory requirements set forth in 35 U.S.C. § 316(d) and 37 C.F.R. § 42.121." *Lectrosonics, Inc. v. Zaxcom, Inc.*, IPR2018-01129, Paper 15 at 4 (PTAB Feb. 25, 2019) (precedential). Accordingly, a patent owner must make a claim listing reproducing each proposed substitute claim, and must make an initial showing to demonstrate the following: (1) the amendment proposes a reasonable number of substitute claims; (2) the proposed claims are supported in the original disclosure (and any earlier filed disclosure for which the benefit of filing date is sought); (3) the amendment responds to a ground of unpatentability involved in the trial; and (4) the amendment does not seek to enlarge the scope of the claims of the patent or introduce new subject matter. *See* 35 U.S.C. § 326(d); 37 C.F.R. § 42.121.

CyWee has included a claim listing reproducing each proposed substitute claim. *See Lectrosonics*, Paper 15, at 8 (citing 37 C.F.R. § 42.121(b)). CyWee also contends that it has proposed a reasonable number of substitute claims, and that the proposed amendments do not enlarge the scope of the claims. RMTA 3–4. LGE does not dispute these contentions. We agree with CyWee, because there is one proposed substitute claim per original challenged claim, and the claim amendments add substantive limitations without removing any limitations from the original claims. *See* RMTA App'x 1–5.

However, LGE contends that CyWee has not met its burden to show that that some of the amendments in proposed substitute claims 20 and 22 respond to a ground of unpatentability involved in the trial, and that the proposed substitute claims do not introduce new subject matter. *See* Opp. RMTA 1–9. We address LGE's contentions in turn.

1. Responding to a Ground of Unpatentability Involved in the Trial

CyWee argues that its proposed amendments are "responsive to a ground for institution" because they add substantive limitations to the proposed substitute claims, in response to the allegations in the Petition that the original claims are unpatentable under § 103. RMTA 4.

In response, LGE argues that CyWee has failed to adequately explain why the additions in limitation 20(h) and a deletion in proposed substitute claim 22 respond to a ground of unpatentability. Opp. RMTA 3–4. In particular, LGE contends that CyWee provides no explanation for how the added phrases "said axial accelerations of" and "of said axial accelerations of said second signal set" in limitation 20(h) respond to a ground of

unpatentability. *Id.* at 3 (emphasis omitted). LGE also argues that in deposition, CyWee's expert Professor LaViola admitted that he did not believe that CyWee's proposed deletion of the word *and* in proposed substitute claim 22 responded to any ground of unpatentability in the trial. *Id.* at 3–4 (citing Ex. 1048, 215:1–19).

We determine that CyWee has met its burden to show that the proposed amendments respond to a ground of unpatentability involved in the trial. Although CyWee's Revised Motion to Amend does not specifically explain the reason for the amendments in limitations 20(h) and 22, other proposed amendments in substitute claims 20 and 22 clearly respond to issues raised in the Petition. "The rule does not require . . . that every word added to or removed from a claim in a motion to amend be solely for the purpose of overcoming an instituted ground." *Lectrosonics*, Paper 15, at 5. Allowing a patent owner to make other amendments to address other potential issues, "when a given claim is being amended already in view of a 35 U.S.C. § 102 or § 103 ground, serves the public interest by helping to ensure the patentability of amended claims." *Id.* at 6 (citing *Veeam Software Corp. v. Veritas Techs., LLC*, IPR2014-00090, Paper 48 at 26–29 (PTAB July 17, 2017)).

2. Support for the Proposed Substitute Claims

We next consider whether the proposed substitute claims introduce new matter in violation of the written description requirement of 35 U.S.C. § 112 para. 1. New subject matter is any addition to the claims that lacks sufficient support in the subject patent's original disclosure. *See TurboCare Div. of Demag Delaval Turbomach. v. Gen. Elec. Co.*, 264 F.3d 1111, 1118 (Fed. Cir. 2001) ("When [an] applicant adds a claim . . . , the new claim[]

must find support in the original specification."). The Board requires that a patent owner show in a motion to amend that there is written-description support in the originally filed disclosure of the subject patent for each proposed substitute claim, and also set forth support in an earlier-filed disclosure for each claim for which the patent owner seeks the benefit of the earlier-filed disclosure's filing date. *See* 37 C.F.R. §§ 42.121(b)(1), 42.121(b)(2).

The test for determining compliance with the written description requirement is not simply the presence or absence of literal support in the specification for the claim language, but rather, whether the disclosure of the application as originally filed reasonably conveys to a person of ordinary skill in the art that the inventor had possession of the claimed subject matter at the time of filing. *Ariad Pharms., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1351 (Fed. Cir. 2010) (en banc); *Vas-Cath, Inc. v. Mahurkar*, 935 F.2d 1555, 1563 (Fed. Cir. 1991); *In re Kaslow*, 707 F.2d 1366, 1375 (Fed. Cir. 1983).

In its Revised Motion to Amend, CyWee contends that each proposed substitute claim "is supported by the original disclosure of the '438 Patent as filed in the '934 Application and/or the related '558 Provisional, thereby reasonably conveying to one of ordinary skill in the art that the inventor was in possession of the claimed subject matter" as of the applicable filing dates. RMTA 5. CyWee also provides a claim listing appendix identifying what it regards as support in the '934 and '558 applications for each of the limitations in proposed substitute claims 20–24. *Id.* at App'x 7–18. In the main text of the Revised Motion to Amend, CyWee specifically addresses only the new limitations introduced by the amendments to proposed substitute claims 20–24. *See id.* at 5–12; *see also* Opp. RMTA 1–2 (citing

Ex. 1048, 56:8–20 (testimony by Professor LaViola that in his expert report supporting the Revised Motion to Amend, "I don't see support based on th[e] prior patent application and the provisional application for the original claims")).

In the proposed substitute claims, CyWee has added the following limitations: (a) the pointing device is "handheld" (proposed substitute claim 20); (b) there is only a "single housing" or "single printed circuit board" (proposed substitute claims 20, 22, and 24); (c) there is a built-in "display device" and associated "display reference frame" (proposed substitute claims 20, 22, and 24); (d) the measurement and predicted measurement are of "said axial accelerations" (proposed substitute claim 20); (e) the pointing device is a "cellular phone" (proposed substitute claims 21 and 24); and (f) the method uses an extended Kalman filter equation (proposed substitute claims 23 and 24); and (g) the method uses a Jacobian to linearize the measured state (proposed substitute claims 23 and 24). *See* RMTA 5–13.

Of these new limitations, LGE challenges CyWee's showing of written description support for (e) and (g), requiring that the pointing device be a "cellular phone" and that the method uses a Jacobian. *See* Opp. RMTA 4–6, 7–8. LGE also challenges support for the original limitation in claims 1, 14, and 19, now carried-over into proposed substitute claims 20, 23, and 24, respectively, requiring the predicted measurement to be calculated "without using any derivatives" of the measured angular velocities. *See id.* at 8–11. In addition, LGE contends that CyWee has failed to provide support for the limitations of the proposed substitute claims as a whole. We address LGE's contentions as well as each of the newly added limitations below, and find that proposed substitute claims 21 and 24 contain new matter, but the

evidence of record does not show that proposed substitute claims 20 or 22–23 contain new matter.

(a) "handheld" (proposed substitute claim 20)

Proposed substitute claim 20 requires that the 3D pointing device be "handheld." RMTA App'x, 1.

CyWee argues that the '558 provisional application "discloses that the 3D pointing device may be 'a remote controller, a joystick or a cellular phone,'" which are all handheld devices. RMTA 6 (quoting Ex. 2017 ¶ 23) (citing Ex. 2017, Fig. 2; Ex. 2015 ¶ 33). CyWee also argues that the '934 application discloses "a handheld 3D pointing device," and specific embodiments including "a mouse of a computer or a pad of a videogame console." RMTA 6 (quoting Ex. 1002, 18 ¶ 2; *id.* at 62–65 (Figs 1–3, 5, 6); Ex. 2015 ¶ 34 (opining that a person of ordinary skill in the art would understand Figure 6 to depict a handheld device)).

These disclosures are sufficient for us to find that the "handheld" requirement does not add new matter, and LGE does not contend otherwise.

(b) "single housing," "single printed circuit board" (proposed substitute claims 20, 22, and 24)

Proposed substitute claim 20 adds that there is a "single" housing and a "single" PCB. RMTA App'x, 1. Proposed substitute claim 22 adds the requirement that the sensor module is "attached to a single PCB," and "wherein the 3D pointing device comprises a single housing unit." *Id.* at 2. Likewise, proposed substitute claim 24 adds the requirement that the sensor module is "attached to a single PCB." *Id.* at 3.

CyWee argues that the '934 application discloses a single PCB and a single housing in Figures 3, 5, and 6. RMTA 8 (citing Ex. 1002, 63–65 (Figs. 3, 5, 6); Ex. 2015 ¶ 37).

These disclosures are sufficient for us to find that the "single" requirements for the housing and PCB do not add new matter, and LGE does not contend otherwise.

(c) built-in "display device" and associated "display reference frame" (proposed substitute claims 20, 22, 24)

Proposed substitute claim 20 recites "a display device built-in to and integrated with the 3D pointing device and associated with a display reference frame, wherein said resultant angles of the resulting deviation in the spatial pointer reference frame are translated to a movement pattern in the display reference frame." RMTA App'x, 2. Proposed substitute claim 22 recites "wherein the 3D pointing device comprises . . . a display device built-in to and integrated with the 3D pointing device and associated with a display reference frame." *Id.* Proposed substitute claim 24 recites "wherein the 3D pointing device comprises . . . a display device built-in to and integrated with the 3D pointing device and associated with a display reference frame." *Id.* at 4.

CyWee argues that the '934 application discloses that the 3D pointing device "'may further comprise[] a built-in display' that may be 'integrated on the housing.'" RMTA 9 (quoting Ex. 1002, 36–37 ¶ 37) (citing Ex. 1002, 65 (Fig. 6)). CyWee also contends that the '934 application "discloses that the claimed device can include 'a mapping program for translating the resultant angles of the resulting deviation in the spatial pointer reference

frame to a movement pattern in a display reference frame.'" *id.* (quoting Ex. 1002, 34 ¶ 33) (citing Ex. 1002, 36–37 ¶¶ 36–38, 47–48, 51, 67 (Fig. 8)); *see also* PO Reply RMTA 4–5 (same).

We also note that the '934 application discloses that "the . . . display reference frame associated with a display may need not to be external to the spatial reference frame in terms of the hardware configuration of the present invention." Ex. 1002, 37 ¶ 37.

These disclosures are sufficient for us to find that this limitation does not add new matter, and LGE does not contend otherwise.[38]

(d) measurement and predicted measurement of "axial accelerations" (proposed substitute claim 20)

Proposed substitute claim 20 adds the requirement that the measured state includes a measurement of "said axial accelerations of" the second signal set and a predicted measurement "of said axial accelerations of said second signal set." RMTA App'x 1–2.

CyWee contends that the '934 application discloses this limitation because the described "measurement" is of axial accelerations Ax, Ay, Az, and the disclosed "predicted measurement" is of predicted measurements Ax′, Ay′, Az′, calculated from the first signal set. RMTA 9–10 (citing Ex. 1002, 34 ¶ 32). Also, CyWee argues that Figure 7 of the '934 application refers to obtaining "measured axial accelerations" and calculating "predicted axial accelerations." *Id.* at 10 (citing Ex. 1002, 66). Professor LaViola also

[38] LGE contends that the '558 provisional application does not disclose a device with a built-in display to which a movement pattern can be translated. Opp. RMTA 4–5 & n.5. Because we find that there is support in the '934 application, which LGE does not contest, we need not address that issue.

testified in his deposition that equation 8 of the '438 patent disclosure would include "the measurement for the axial acceleration" and "the predicted acceleration." *Id.* (quoting Ex. 1028, 31).

These disclosures are sufficient for us to find that this limitation does not add new matter, and LGE does not contend otherwise.

(e) "cellular phone" (proposed substitute claims 21, 24)

Proposed substitute claim 21 recites "wherein the 3D pointing device is a cellular phone," and proposed substitute claim 24 similarly recites "wherein the 3D pointing device comprises a cellular phone." RMTA App'x 2–4.

CyWee argues that the '558 provisional application discloses that the 3D pointing device may be "a cellular phone," and that "[t]he '558 Provisional is incorporated by reference into the '934 Application." RMTA 10 (quoting Ex. 2017 ¶ 23) (citing Ex. 1002, 18).

LGE responds that CyWee "may not rely on essential material (disclosure of a 'cellular phone') present only in the incorporated-by-reference provisional application." Opp. RMTA 6 (citing 37 C.F.R. § 1.57(d); *Droplets v. E*Trade*, 887 F.3d 1309, 1318 (Fed. Cir. 2018); *Sanofi-Aventis U.S. LLC v. Astrazeneca Pharm. LP*, IPR2016-00354, Paper 7 at 10 (PTAB June 28, 2016)).

We agree with LGE that the "cellular phone" limitation is essential material. According to 37 C.F.R. § 1.57(d), "'[e]ssential material' is material that is necessary to . . . [p]rovide a written description of the claimed invention . . . as required by 35 U.S.C. 112 [para. 1]." *Id.* Because the "cellular phone" limitation is necessary to provide a written description in

proposed substitute claims 21 and 24, it is "essential material" under this definition, and CyWee does not argue otherwise.

Essential material "may be incorporated by reference, but only by way of an incorporation by reference to a U.S. patent or U.S. patent application publication." *Id.*; *Droplets*, 887 F.3d at 1318. In the oral hearing, CyWee argued that a provisional application is a "U.S. patent application publication" under this rule. Tr. 69:9–72:13 (citing *Nomadix, Inc. v. Second Rule LLC*, No. CV0701946DDPVBKX, 2009 WL 10668158, at *26 (C.D. Cal. Jan. 16, 2009)).

We disagree that *Nomadix* supports CyWee's position. In that case, the district court held that an incorporation by reference to a provisional application was sufficient under 35 U.S.C. § 112, where at the time the non-provisional application was filed, "no regulation governed incorporation by reference." *Nomadix*, 2009 WL 10668158, at *24. But according to the court, "If § 1.57 applied to the [challenged] patent, there would be no question that the . . . provisional application was improperly incorporated." *Id.*

Because a U.S. provisional application is not a "U.S. patent or U.S. patent application publication," the '934 application's incorporation by reference of the '558 provisional application was ineffective as to the "cellular phone" embodiment.

CyWee also contends that the '934 application independently discloses a "cellular phone" because it discloses that the 3D pointing device "may further comprise[] a built-in display" that may be "integrated on the housing." *Id.* (quoting Ex. 1002, 36–37 ¶ 37) (citing Ex. 1002, 65 (Fig. 6)). CyWee contends that a person of ordinary skill in the art "would understand

that a cellular phone is a device with a "built-in display . . . integrated on the housing." *Id.* (citing Ex. 2015 ¶ 43; Ex. 2020, 3, 30–34 (illustrating cellular phones with built-in displays from the relevant time period)).

This argument is not persuasive, because even if a person of ordinary skill in the art would have understood that cellular phones have a built-in display, CyWee does not suggest that *only* cellular phones had built-in displays at the time of the claimed invention. So simply disclosing a built-in display is not equivalent to disclosing a cellular phone.

Finally, CyWee contends that Figure 6 of the '934 application depicts a cellular phone. *Id.* at 11 (citing Ex. 1002, 65 (Fig. 6)). Figure 6 of the '934 application is reproduced below:

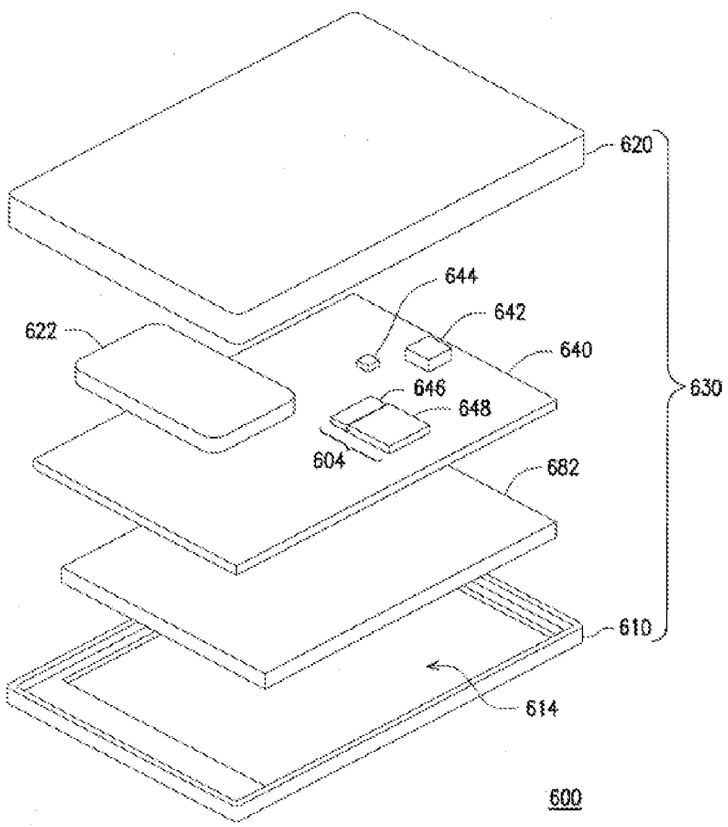


FIG. 6

Ex. 1002, 65. Figure 6 "is an exploded diagram showing a 3D pointing device 600." *Id.* at 36 ¶ 37. The device includes housing 630, which includes top and bottom covers 610 and 620, respectively. *See id.* at 37 ¶ 37. Adjacent to top cover 610 is built-in display 682, which "may . . . be integrated on the housing 630." *Id.*

LGE disagrees that Figure 6 reasonably conveys possession of a cellular phone, because it "does not depict any components for connecting with a cellular network (antenna, SIM card, etc.) or even components of a phone (such as a microphone and speaker)." Opp. RMTA 4 (citing Ex. 1051 ¶¶ 27–28).

We agree with LGE that the 3D pointing device in Figure 6 of the '934 application is not explicitly a cellular phone, and we find that the figure does not reasonably convey to a person of ordinary skill in the art that the inventors had possession of a cellular phone embodiment at the time of filing.

For the above reasons, we find that CyWee has failed to show that the "cellular phone" limitations in proposed substitute claims 21 and 24 would not introduce new matter.

(f) "Extended Kalman Filter equation" (proposed substitute claims 23, 24)

Proposed substitute claim 23 recites "said angular velocities ω_x, ω_y, ω_z and said second quaternion are represented by at least one Extended Kalman Filter equation." RMTA App'x 3. Similarly, proposed substitute claim 24 recites "said measured angular velocities ω_x, ω_y, ω_z and said second quaternion are represented by at least one Extended Kalman Filter equation." *Id.* at 4.

CyWee contends that equations 5–10 of the '934 application are extended Kalman filter equations, even though the application does not use that term. RMTA 12. (citing Ex. 1002, 44–45 ¶ 47; Ex. 2015 ¶ 47). Of these equations, CyWee argues that "equation 5 represents both the angular velocities and second quaternion." *Id.* (citing Ex. 1028, 34 (LaViola deposition)).

These disclosures are sufficient for us to find that the extended Kalman filter limitation does not add new matter, and LGE does not contend otherwise.

(g) a "Jacobian" to linearize the measured state (proposed substitute claims 23, 24)

Proposed substitute claim 23 recites "the step of using at least one Jacobian to linearize said measured state." RMTA App'x 3. Similarly, proposed substitute claim 24 recites "at least one Jacobian is used to linearize said measured state." *Id.* at 4.

Relying on the testimony of Professor LaViola, CyWee argues that among extended Kalman filter equations 5–10 of the '934 application, equations 6, 7, and 10 are Jacobians that linearize the measured state. RMTA 12 (citing Ex. 2021 ¶ 46; Ex. 1028, 24).

LGE contends that CyWee's argument cites only to Professor LaViola's testimony and not to the '934 application. Opp. RMTA 7. LGE also argues that CyWee relies on inherency for this limitation, and has not adequately shown that any of the equations in the '934 application necessarily linearizes a measured state that includes "predicted axial accelerations." *Id.* at 7–8 (citing *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999)); *see also* Sur-Reply RMTA 3 (arguing that Professor LaViola stated that the "Jacobian" limitation was not in the patent "specifically, but I believe **it's *implied***" (quoting Ex. 1048, 241:4–5)). Specifically, LGE argues that in his deposition, Professor LaViola identified the function *h* in equation 10 as the "measured state," but when asked whether it is possible to have an *h* function that does *not* include a predicted axial acceleration, Professor LaViola answered, "**Yes.** But it wouldn't work very well in my opinion." *Id.* at 4 (quoting Ex. 1048, 243:2–7).

We do not find LGE's arguments persuasive. First, we interpret Professor LaViola's deposition testimony as his agreement with opposing

counsel that, in a hypothetical situation, equation 10 could be modified to exclude predicted axial accelerations—not that equation 10 fails to necessarily describe a Jacobian that linearizes the measured state.

Second, we find unpersuasive LGE's contention that the patent disclosure as a whole, including equation 10, fails to show that the inventors had possession of a Jacobian that linearizes a measured state. The '934 application discloses that "the measured state correlated to the abovementioned second axial accelerations and in relation to the axial accelerations of accelerometers and current state may be obtained based on [equation 8]," which includes the *h* function. Ex. 1002, 27:13–16 ¶ 47. This passage refers to the "accelerations of accelerometers" (i.e., the measured axial accelerations) and the "second axial accelerations" (i.e., the predicted axial accelerations) discussed in the preceding paragraphs of the disclosure. *See id.* at 25 ¶ 45 ("[T]wo sets of axial accelerations may be obtained for the measured state of the six-axis motion sensor module; one may be the measured axial accelerations Ax, Ay, A[z] . . . and the other may be the predicted axial accelerations Ax′, Ay′, Ax′ . . . .").

Thus, the text of the '934 application supports Professor LaViola's testimony that equation 10 linearizes the measured state (including both measured and predicted axial accelerations), and CyWee's position that the "Jacobian" limitations have written description support. Thus, we do not find that the "Jacobian" limitations in proposed substitute claims 23 and 24 add new matter. [39]

[39] Our finding relates only to support for this limitation in equation 10 of the '934 application. While the evidence suggests that equations 6 and 7 represent Jacobians, they appear to be associated with the state model or

(h) calculating the predicted measurement "without using any derivatives" of the measured angular velocities (proposed substitute claims 20, 22, 24)

Proposed substitute claim 20 require that the calculation of the predicted measurement of the axial accelerations of the second signal set is obtained based on the first signal set "without using any derivatives of the first signal set." RMTA App'x 1–2. Similarly, proposed substitute claims 22 and 24 require that the calculation is performed "without using any derivatives of the measured angular velocities ω_x, ω_y, ω_z." *Id.* at 3–4.

This limitation was not in the original claims, as filed. *See* Ex. 1002, 54–60. During prosecution, the applicant added the limitation in a new claim 21 (now claim 19), and then before issuance, the Examiner introduced the limitation through an examiner amendment to claims 1 and 16 (now claims 1 and 14). *Id.* at 181, 199–200. The purpose of the amendment was to overcome a prior art reference. *See id.* at 185. Thus, these limitations are found in the issued claims of the '438 patent, and are also present in the claims that CyWee proposed in its original Motion to Amend. *Compare* MTA App'x 1–4, *with* RMTA App'x 1–4.

LGE acknowledges that the '934 application refers to "calculating predicted axial accelerations . . . based on the measured angular velocities," but contends that the application does not explain how to perform the calculation or how to do so without using derivatives. Opp. RMTA 8–9

"current state," rather than the measurement model or "measured state." *See* Ex. 1028, 24:7–11 (Professor LaViola's testimony that equations 6, 7, and 10 "linearize the state and measurement equations"); Ex. 1002, 27:1–21 ¶ 47 (text introducing equations 5–7 refers to the "current state," while text introducing equations 8–10 refers to the "measured state").

(citing Ex. 1002 ¶ 32, 36, 40–41, Figs. 7–8; Ex. 1041 ¶ 38–39). CyWee disagrees, based on the text of the '934 application as well as testimony by Professor LaViola. Reply RMTA 6–7 (citing Ex. 1001, 8:50–56; Ex. 1048, 135, 164:12–16, 164:20–22, 225:24–226:2).

As we discuss above, this is a new argument raised by LGE for the first time in its Opposition, which does not affect our decision because we determine that proposed substitute claims 20, 22, and 24 which have this limitation are unpatentable under § 103 and proposed substitute claim 24 introduces new matter. *See supra* part V.B.1. Therefore, we need not decide this issue.

(i) Support for the Proposed Substitute Claims as a Whole

LGE argues that CyWee is required to present support for the proposed substitute claims as a whole, and not just for the amended features, and that this support "must be set forth in the motion to amend itself, not the claim listing." Opp. RMTA 2 (emphasis omitted) (quoting *Lectrosonics*, Paper 15, at 8). According to LGE, allowing CyWee to meet its burden of showing written description support in a claim listing renders CyWee's 25-page limit meaningless. Sur-Reply RMTA 2 n.4. LGE also cites a non-precedential case in which the Board denied a motion to amend because the patent owner did not show support for the claims as a whole. *Id.* at 2–3 (citing *Lippert Components v. Days Corp.*, IPR2018-00777, Paper 28 at 51–52, 2019 WL 4674259 (PTAB Sept. 24, 2019)).

LGE's argument is equally applicable to CyWee's original Motion to Amend. *Compare* MTA Claim Listing App'x, *with* RMTA Claim Listing App'x. And ZTE could have raised this issue in its Opposition to the Motion

to Amend. Thus, this is one of LGE's new arguments that we have declined to address in our decision. *See supra* part V.B.1. Ultimately, we do not need to address this issue because we determine that proposed substitute claims 20–24 are unpatentable under § 103 and proposed substitute claims 21 and 24 introduce new subject matter. *See supra* part V.B.1.

(j) Summary

To summarize, we find for the above reasons that proposed substitute claims 21 and 24 contain new matter, but that proposed substitute claims 20 or 22–23 do not contain new matter. As such, we find that proposed substitute claims 21 and 24 are unpatentable for failing to satisfy the written description requirement under 35 U.S.C. § 112, first paragraph.

D. PATENTABILITY OF THE PROPOSED SUBSTITUTE CLAIMS

Having considered whether CyWee has met its statutory and regulatory burden for a motion to amend, we next consider whether the record as a whole shows that the proposed substitute claims are patentable.

The Board must assess the patentability of proposed substitute claims "without placing the burden of persuasion on the patent owner." *Aqua Prods.*, 872 F.3d at 1328; *see Lectrosonics*, Paper 15 at 3–4 (discussing *Aqua Products* and the burden of persuasion). After *Aqua Products*, the Federal Circuit further clarified the burden of persuasion in *Bosch Automotive Service Solutions, LLC v. Matal*, 878 F.3d 1027 (Fed. Cir. 2017), *amended by Bosch Automotive Service Solutions, LLC v. Iancu*, No. 2015-1928 (Fed. Cir. Mar. 15, 2018).

According to *Aqua Products*, *Bosch*, and *Lectrosonics*, a patent owner does not bear the burden of persuasion to show that the proposed substitute

claims are patentable. Rather, ordinarily "the petitioner bears the burden of proving that the proposed amended claims are unpatentable by a preponderance of the evidence." *Bosch*, 878 F.3d at 1040 (as amended on rehearing); *Lectrosonics,* Paper 15 at 3–4. To determine whether a petitioner has proven the substitute claims are unpatentable, the Board focuses on "arguments and theories raised by the petitioner in its petition or opposition to the motion to amend." *Nike*, 955 F.3d at 51. The Board itself also may justify any finding of unpatentability by referring to evidence of record in the proceeding. *Lectrosonics*, Paper 15 at 4 (citing *Aqua Products*, 872 F.3d at 1311 (O'Malley, J.)).

LGE contends that proposed substitute claims 20–24 are unpatentable under 35 U.S.C. §§ 103(a), 112 para. 1, and 101, and that proposed substitute claims 20 and 21 are unpatentable under § 112 para. 2. *Id.* at 15–25. The table below is a summary of the unpatentability grounds LGE advances in its Opposition to the Revised Motion to Amend:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
20–22, 24	112 para. 1	Enablement
20, 21	112 para. 2	Indefiniteness
20–24	103(a)	Withanawasam,[40] Bachmann, Bachmann2[41]
20–24	103(a)	Yamamoto,[42] Bachmann, Bachmann2
20–24	101	Eligibility

We address LGE's unpatentability arguments in the sections below.

[40] Withanawasam, *supra* note 17.

[41] Bachmann2, *supra* note 15.

[42] Yamamoto, US 2009/0201249 A1 (published Aug. 13, 2009) (Ex. 1050).

1. Definiteness, Enablement, Estoppel, and Patent Eligibility

LGE contends (A) that proposed substitute claim 20(i) introduces a process step that makes proposed substitute apparatus claims 20 and 21 indefinite (Opp. RMTA, 6–7); (B) that the '438 patent disclosure does not adequately enable certain aspects of limitations 20(g), 20(h), 22(c), 22(e)–(g), 24(c), or 24(e)–(g) (*id.* at 9–15); (C) that CyWee is estopped under 37 C.F.R. § 42.73 from making the proposed amendments (*id.* at 15); and (D) that the challenged claims are ineligible subject matter under 35 U.S.C. § 101 (*id.* at 24–25).

LGE's definiteness, enablement, estoppel, and patent eligibility arguments relate to limitations found in the original claims and in the claims that CyWee proposed in its original Motion to Amend. *Compare* MTA App'x 1–4, *with* RMTA App'x 1–5. As we discuss above, these new arguments by LGE do not affect our decision because we determine that proposed substitute claims 20–24 are unpatentable under § 103 and that proposed substitute claims 21 and 24 introduce new matter. *See supra* part V.B.1. Therefore, we need not decide these issues.

2. Obviousness of Proposed Substitute Claims 20–22 over Withanawasam and Bachmann

LGE contends that proposed substitute claims 20–22 are unpatentable under 35 U.S.C. § 103(a) as obvious over Withanawasam in view of Bachmann. Opp. RMTA 15–22. For the reasons below, we determine that a preponderance of the evidence supports LGE's contention. We note that in *Google v. CyWee*, the Board determined that a proposed substitute for claim 1 with similar amendments was unpatentable based on the same

Withanawasam–Bachmann combination. *See* IPR2018-01258, Paper 86, at 74–85. To the extent that CyWee's proposed substitute claim 20 is identical to the proposed substitute claim held unpatentable in that case, we adopt the Board's findings in that final written decision. Below, we discuss the evidence as it relates to CyWee's proposed substitute claims in this case, with particular emphasis on the new claim features that are different from the features of the proposed claims that the Board addressed in *Google v. CyWee*.

(a) Overview of Withanawasam

Withanawasam has a filing date of June 3, 2009. Ex. 1049, code (22). This predates November 11, 2010, the filing date of the '934 application which issued as the '438 patent. Ex. 1001, codes (21), (22). It also predates January 6, 2010, the filing date of the provisional '558 application, to which the '438 patent claims priority. Ex. 1001 1:13–15, code (60). CyWee does not allege that any of the proposed substitute claims antedate Withanawasam. *See* Reply RMTA 10–11.[43] Thus, we conclude that Withanawasam is prior art to the proposed substitute claims under § 102(e).[44]

[43] In *Google v. CyWee*, CyWee contended that its proposed substitute claims were entitled to an earlier priority date than Withanawasam, based on the conception and diligent reduction to practice of the claimed inventions. *See* IPR2018-01258, Paper 86, at 68. The Board determined that CyWee had provided insufficient corroborating evidence to support that contention. *Id.* at 74.

[44] 35 U.S.C. § 102(e) (2006). *See supra* note 26.

Withanawasam describes "an integrated sensor device" with a "micro-electro-mechanical systems (MEMS) sensor . . . and at least one additional sensor, such as a magnetic sensor." Ex. 1049 ¶¶ 2, 9, code (57). Figure 1 of Withanawasam, reproduced below, is a block diagram of such an integrated device:

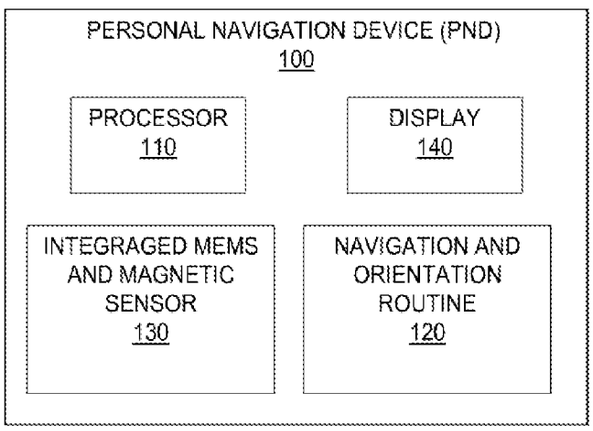


FIG. 1

Figure 1, above, depicts personal navigation device ("PND") 100, "comprising an integrated MEMS and magnetic sensor 130." *Id.* ¶ 11. PND 100 "can be a mobile (hand-held) navigation device, a smart phone, or any similar mobile device configured to aid a user in navigation and applications requiring orientation information." *Id.* The device includes processor 110, which is "configured to run a navigation and orientation routine module 120." *Id.* Display 140 "can comprise a liquid crystal display (LCD), a digital display, or the like," and it presents navigation information that "includes positional information, orientation information, maps, compass directions, a predetermined path, or any other information useful in navigation." *Id.* "The

components of the PND 100 are communicatively coupled to one another as needed using suitable interfaces and interconnects." *Id.* ¶ 12.

Withanawasam states that "orientation information," or in other words, "information relating to the present orientation of the PND 100, . . . can be determined using the integrated MEMS and magnetic sensor 130." Ex. 1049 ¶ 12. Sensor 130 provides information "relating to acceleration, roll and directional data (that is, relating to a compass direction)," and "can use three axes of sensing for acceleration and gyroscope data in one single integrated MEMS sensor." *Id.* Alternatively, the device can comprise "a plurality of integrated MEMS sensors 130, each for a different axis of acceleration or gyroscope data." *Id.*

(b) The Combination of Withanawasam and Bachmann

According to LGE, Withanawasam teaches all the "hardware" recited in proposed substitute claims 20–24, including the recited handheld 3D pointing device with a built-in display and integrated sensors. Opp. RMTA 17. But LGE states that Withanawasam "does not explicitly disclose the mathematical algorithms used with its sensors to output orientation." *Id.* at 17–18. LGE relies on Bachmann to teach the recited algorithm for updating the orientation state in conjunction with Bachmann's nine-axis sensors. *See id.* at 18–22. According to LGE, a person of ordinary skill in the art "would have been motivated to select known sensors and a known method for mathematically fusing sensor data, like Bachmann's, to output orientation values." *Id.* at 18 (citing Ex. 1051 ¶¶ 57–58).

LGE also argues that a person of ordinary skill in the art would have understood that using Bachmann's nine-axis sensor in Withanawasam's

device would result in the following advantages: (i) a person of ordinary skill in the art could "choose sensors and fuse sensor data accurately"; (ii) "Bachmann's sensor [would] allow[] Withanawasam's device to obtain orientation in all rotational degrees of freedom (roll, pitch and yaw)"; and (iii) Bachmann's sensor and fusion method would allow for greater precision and error control because of overdetermination. *Id.* (citing Ex. 1051 ¶¶ 57–58).

LGE also contends that a person of ordinary skill in the art "would have recognized from Bachmann that using [a] quaternion-based filter processing method is computationally more efficient than using spatial (e.g., Euler) angle calculations and avoids singularities that might otherwise occur at certain sensor orientations." *Id.* (citing Ex. 1007, 5:33–7:31; Ex. 1051 ¶ 59).

LGE characterizes this combination of Withanawasam and Bachmann as "nothing more than the combination of known elements (Withanawasam's device plus Bachmann's nine-axis sensor and fusion technique) to achieve an expected improvement (a computationally efficient fusion method of Bachmann)." Opp. RMTA 18; *see also* Ex. 1051 ¶ 59 (Professor Michalson agreeing with the motivation to combine as articulated by Professor Sarrafzadeh, the petitioner's expert in *Google v. CyWee* (citing Ex. 1057 ¶¶ 55–69)).

According to LGE, this combination "would have been achievable by the ordinary skill of a [person of ordinary skill in the art] with a reasonable expectation of success." *Id.* (citing Ex. 1051 ¶ 60). In particular, Professor Michalson notes that Withanawasam's device includes computing hardware sufficient to run its navigation and orientation routine, and opines that

"[t]here is nothing in Withanawasam that would prohibit running a navigation and orientation routine module such as that described by Bachmann. This would merely involve the routine engineering tasks of compiling the software of Bachmann for execution on the processor of Withanawasam." Ex. 1051 ¶ 60.

CyWee does not specifically contest LGE's general arguments, above, as to the combination of Withanawasam and Bachmann. *See* Reply RMTA 10–11. We credit Professor Michalson's testimony and find it persuasive that a person of ordinary skill in the art would have had the knowledge and motivation necessary to implement Bachmann's algorithm on Withanawasam's hardware. We also find Professor Michalson's testimony persuasive that an ordinarily skilled artisan would have been motivated to choose Bachmann's nine axis sensors in implementing Withanawasam's device.

This is consistent with the Board's earlier determination in *Google v. CyWee*, IPR2018-01258, Paper 86 (Final Written Decision), which considered the same prior art combination, as applied to similar claims, and likewise determined that a person of ordinary skill in the art would have had reason to combine Bachmann's algorithm and sensors with Withanawasam's device. *See* Ex. 1056, 76–80, 86.

LGE also addresses the individual limitations of proposed substitute claims 20–24, and we address those arguments in the sections below.

(c) Proposed Substitute Claim 20 (Withanawasam and Bachman)

(1) Preamble

The preamble of proposed substitute claim 20 recites "[a] three-dimensional (3D) pointing device, which is handheld, subject to movements and rotations in dynamic environments." RMTA App'x A, 1. Thus, CyWee's proposed amendment to the preamble requires that the 3D pointing device be "handheld."

LGE contends that Withanawasam's device is handheld. Opp. RMTA 19 (citing Ex. 1049 ¶ 11). CyWee does not contest LGE's argument or otherwise argue that Withanawasam fails to disclose the preamble of claim 20, including the added "handheld" limitation. *See* Reply RMTA 10–11.

We find LGE's argument persuasive. *See* Ex. 1049 ¶ 11 ("The PND 100 can be a mobile (hand-held) navigation device, a smart phone, or any similar mobile device configured to aid a user in navigation and applications requiring orientation information.").[45] Because we find that Withanawasam discloses the preamble, we need not determine whether the preamble is limiting.

(2) Limitations 20(a)–(d)

Limitation 20(a) recites "a single housing associated with said movements and rotations of the 3D pointing device in a spatial pointer reference frame." RMTA App'x A, 1. Limitation 20(b) recites "a single

[45] This proposed preamble is identical to CyWee's proposed preamble amending original claim 1 in *Google v. CyWee*, and the Board likewise found that Withanawasam discloses the preamble. *See* IPR2018-01258, Paper 86, at 81–83.

printed circuit board (PCB) enclosed by the housing." *Id.* Limitations 20(c) and (d) recite "a six-axis motion sensor module attached to the PCB" with a rotation sensor and an accelerometer for measuring rotations and axial accelerations associated with the 3D device's spatial pointer reference frame. *See id.* Limitations 20(c) and (d) are unchanged from original claim 1 and the corresponding limitations that the Board previously addressed in *Google v. CyWee*. *Compare* RMTA App'x. A, 1, *with* Ex. 1001, 18:61–19:3, *and* Ex. 1056, 60. Thus, in the Revised Motion to Amend, the new feature of limitations 20(a)–(d) is that the six-axis sensor module, including the motion sensors, is attached to the device's "single" PCB, which is enclosed by the device's "single" housing.

LGE argues that Withanawasam discloses a single housing enclosing a single PCB. Opp. RMTA 19 (citing Ex. 1049 ¶¶ 1, 10). Alternatively, LGE argues that "Withanawasam's disclosure of a smartphone would have motivated a [person of ordinary skill in the art] to use a single housing to enclose Bachmann's sensor module on a single PCB (as Withanawasam teaches) to avoid a user having to directly touch electronic components." *Id.* (citing Ex. 1051 ¶ 61). LGE also argues that Bachmann teaches using a single nine-axis MARG sensor module, and that a person of ordinary skill in the art would have had reason to mount that sensor module on Withanawasam's single PCB. *Id.*

In response, CyWee argues that "LG[E] makes no attempt to show that *Withanawasam* encloses all these components in a single housing, and contrary to LG[E]'s argument (Paper 62, 19), the mere mention of a 'smartphone' does not teach this requirement." Reply RMTA 10. CyWee also contends that Bachmann "teaches tracking the position of human limbs

relative to each other using multiple sets of sensors in multiple housings. *Id.* at 11.

We find LGE's argument persuasive to show that Withanawasam teaches limitations 20(a)–(d) in light of the teachings in Bachman. Although Withanawasam does not explicitly disclose a single housing, it teaches minimizing the PCB footprint in a packaged device. Ex. 1049 ¶ 10 ("The present integrated MEMS sensor devices . . . reduce the amount of semiconductor substrate material used in the device and concurrently reduce the PCB footprint of the packaged device."). Withanawasam also teaches "[i]ntegrating an accelerometer . . . or a gyroscope and magnetic sensors into a common semiconductor device." *Id.*

Bachmann, likewise, teaches a device with integrated sensors, *see* Ex. 1007, 14:37–59, and we find that a person of ordinary skill in the art would have had reason to choose Bachmann's sensor module for integration onto Withanawasam's PCB. We credit Professor Michalson's testimony that "[i]n the combination with Bachmann, . . . a [person of ordinary skill in the art] would have simply enclosed Bachmann's nine-axis MARG sensor module in the single housing, instead of Withanawasam's integrated MEMS sensor." Ex. 1051 ¶ 61.

We also credit Professor Michalson's testimony that a person of ordinary skill in the art would have understood Withanawasam's disclosure of using the packaged sensor system in a smartphone or other similar mobile navigation device to suggest the use of a single housing. *See* Ex. 1051 ¶ 61. Also, we find his testimony persuasive that an ordinarily skilled artisan would have been motivated to ensure that sensitive electronic components of the smartphone are protected and not in contact with the user's hand. *Id.*

CyWee's argument that Bachmann teaches multiple sets of sensors and multiple housings (Reply RMTA 10) is not persuasive, because LGE relies on the combination of Withanawasam and Bachmann to teach these limitations, not Bachmann alone. *See In re Keller*, 642 F.2d 413, 426 (CCPA 1981) ("[O]ne cannot show non-obviousness by attacking references individually where, as here, the rejections are based on combinations of references.")

Thus, we find that LGE has shown that Withanawasam, in light of Bachmann, teaches limitations 20(a)–(d).

(3) Limitations 20(e)–(g)

Limitations 20(e)–(g) are identical to the limitations in original claim 1 as well as the corresponding limitations that the Board previously addressed in *Google v. CyWee*. *Compare* RMTA App'x. A, 1, *with* Ex. 1001, 19:4–23, *and* Ex. 1056, 60–61. With respect to these limitations, we adopt the Board's prior analysis in *Google v. CyWee*, which also applied the Withanawasam–Bachmann combination to these limitations. *See* Ex. 1056, 80–81. We address LGE's additional arguments below, which CyWee does not specifically contest.

Limitation 20(e) recites, in part, "a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting said first and second signal sets thereof." RMTA App'x A, 1. LGE argues that Withanawasam discloses "communicatively coupling components using 'suitable interfaces and interconnects,'" and that these interfaces and interconnects form the recited data transmitting unit. Opp. RMTA 20 (citing Ex. 1049 ¶ 11; Ex. 1051 ¶ 62).

Limitation 20(e) also recites "a computing processor for receiving and calculating said first and second signal sets from the data transmitting unit." RMTA App'x A, 1. LGE contends that "either the processor 110 of Withanawasam . . . or the processor 403 in Bachmann's Figure 4 would have been used as the recited computing processor in the claims." Opp. RMTA 20 (citing Ex. 1049, Fig. 1, ¶ 11–12).

Limitation 20(f) recites "communicating with the six-axis motion sensor module to calculate a resulting deviation comprising resultant angles in said spatial pointer reference frame." RMTA App'x A, 1. LGE contends that "Bachmann's filtering process yields an 'orientation of the tracked object.'" Opp. RMTA 21 (citing Ex. 1007, 10:10–14). LGE also points to orientation output $\hat{q}$ in Bachmann's Figure 3, which according to LGE "is a quaternion that represents a rotation from the sensor-based coordinate system (the spatial reference frame of claim 1) to a flat-Earth coordinate system." *Id.* LGE contends that "[i]t would have been obvious to convert the orientation output quaternion into Euler angles (roll, pitch, and yaw) to make the underlying orientation information easier to interpret by a human user." *Id.* (citing Ex. 1049 ¶ 11).

Limitation 20(g) recites a comparison between the "first signal set" and the "second signal set" using an update program "to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set." RMTA App'x, 1. LGE argues that this comparison is "disclosed by the combination [of Withanawasam and Bachmann] when the correction factor $\dot{q}_{\varepsilon}$ i[n] Bachmann's Figure 3 is formed (steps 34–41). Opp. RMTA 21. We note that

steps 34–41 of Bachmann's Figure 3 include the comparison between $\vec{y}_0$ and $\vec{y}(\hat{q})$ (boxes 34, 35, and 35a). *See supra* part IV.C.5(g).

Regarding the above uncontested arguments by LGE, we credit Professor Michalson's supporting testimony (Ex. 1051 ¶¶ 62–63) and find LGE's arguments persuasive that the combination of Withanawasam and Bachmann teaches limitations 20(e)–(g).

(4) Limitation 20(h)

Limitation 20(h) recites "wherein the measured state includes a measurement of said axial accelerations of said second signal set and a predicted measurement of said axial accelerations of said second signal set obtained based on the first signal set without using any derivatives of the first signal set." RMTA App'x A, 1–2. Thus, CyWee proposes adding limitations requiring that both the "measurement" and "predicted measurement" are "of said axial accelerations of said second signal set."

LGE argues that Bachman teaches this limitation by disclosing "measured axial accelerations in box 34 (which become part of $\bar{y}_0$) and of predicted or calculated axial accelerations in the quaternion $\bar{y}(\hat{q})$, which is sufficient to meet limitation 20(h)." Opp. RMTA 21 (citing Ex. 1030 ¶¶ 97–99). LGE contends that "[t]he measured state[] includes measured and predicted acceleration data, but that measured state need not be included in one parameter." *Id.* at 21–22 (citing Ex. 1051 ¶ 64).

In response, CyWee argues that Bachmann does not teach a measured state that includes *both* the recited "measurement" of axial accelerations and the "predicted measurement" of axial accelerations based on the angular velocities (the first signal set). Reply RMTA 11; *see also* RMTA 17–18. According to CyWee, box 34 in Bachmann's Figure 3, which LGE contends

are the axial accelerations (second signal set) "cannot possibly output a predicted measurement based on the first signal set (angular velocities) because angular velocities are not input to box 34 or listed within box 34." Reply RMTA 11. CyWee also disagrees that the elements of vector $\bar{y}(\hat{q})$ are the claimed "predicted measurements" because "(i) *Bachmann* does not describe $\bar{y}(\hat{q})$ as predicted measurements and (ii) $\bar{y}(\hat{q})$ is not part of box 34" which LGE alleges is the recited "measured state." *Id.* (citing Opp. RMTA, 17; RMTA, 18–19). Rather, "$\bar{y}(\hat{q})$ is on the opposite side of the operation at the top of FIG. 3 than the alleged measured state at box 34." *Id.* (citing RMTA, 18–19). CyWee raised essentially the same arguments above in the context of original claim limitation 1(n) above. *See supra* part IV.C.5(k).

We agree with LGE that, as recited in original claim 1 and proposed substitute claim 20, there is no requirement that the "measured state" exist as a single parameter such as $\bar{y}_0$ in box 34 of Bachman's Figure 3. LGE identifies the "measured state" as the *combination* of $\bar{y}_0$ and $\bar{y}(\hat{q})$ (boxes 34 and 35a). *See* Sur-Reply RMTA 9–10 (citing Ex. 1051 ¶¶ 64, 66).

As a matter of claim construction, the evidence of record suggests that a person of ordinary skill in the art reading the '438 patent as a whole would have understood that the "measurement" of axial accelerations and the "predicted measurement" of axial accelerations can be two distinct sets of parameters. When describing the "measured state" of the six-axis motion sensor module referenced in steps 725 and 730 of Figure 7 of the '438 patent, the inventors identify "measured axial accelerations Ax, Ay, Az" which are obtained from the second signal set, and a distinct set of "predicted axial accelerations Ax′, Ay′, Az′," which are calculated from the

measured angular velocities (i.e., the first signal set). *See* Ex. 1001, 12:61–13:13.

Measured axial accelerations Ax, Ay, Az are analogous to Bachmann's measurement vector $\bar{y}_0$,[46] both of which correspond to the "measurement of said axial accelerations of said second signal set" recited in limitation 20(h). Predicted axial accelerations Ax′, Ay′, Az′ are analogous to Bachman's computed measurement vector $\bar{y}(\hat{q})$,[47] both of which correspond to the "predicted measurement of said axial accelerations of said second signal set obtained based on the first signal set" recited in limitation 20(h).

We also find CyWee's argument that Bachmann "does not describe $\bar{y}(\hat{q})$ as predicted measurements" unconvincing. Reply RMTA 11. Bachmann describes $\bar{y}(\hat{q})$ as a "computed measurement vector," and as "a vector to be fitted to" the measured data points in vector $\bar{y}_0$. Ex. 1007, 9:2, 9:34–35. We find that a person of ordinary skill in the art would have understood this to teach that $\bar{y}(\hat{q})$ is a predicted measurement of axial accelerations. Like $\bar{y}(\hat{q})$ in Bachmann, predicted axial accelerations Ax′, Ay′, and Az′ in the '438 patent are "calculated based on the . . . current state or quaternion in relation to the measured angular velocities." Ex. 1001, 13:11–13.

---

[46] Measurement vector $\bar{y}_0$ contains, among other things, measured axial accelerations h_1, h_2, h_3. *See* Ex. 1007, 8:47–50, Fig. 3 box 34.

[47] Computed measurement vector $\bar{y}(\hat{q})$ contains, among other things, estimated axial accelerations h_1, h_2, h_3 which are calculated from the equation $h = \hat{q}^{-1} m \hat{q}$, where $\hat{q}$ is the estimated orientation quaternion and m is a unit vector in quaternion form representing gravity. *See* Ex. 1007, 7:60–61, 8:52–55, 8:63–9:8, 10:13–14, Fig. 3 box 35.

Accordingly, we determine that LGE has shown that the combination of Withanawasam and Bachmann teaches limitation 20(h).

(5) Limitation 20(i)

Limitation 20(i) recites "a display device built-in to and integrated with the 3D pointing device and associated with a display reference frame, wherein said resultant angles of the resulting deviation in the spatial pointer reference frame are translated to a movement pattern in the display reference frame." RMTA App'x A, 2. This limitation is identical to a corresponding proposed limitation that the Board considered in *Google v. CyWee*. *See* IPR2018-01258, Paper 86, at 61, 83–85. In that case, the Board determined that the Bachmann–Withanawasam combination teaches a built-in display device and the other requirements of limitation 20(i). *See id.* at 83–85.

LGE, likewise, argues that Withanawasam "includes a built-in display with its own display reference frame per 20(i)." Opp. RMTA 19 (citing Ex. 1049 ¶¶ 1, 11–12).

In response, CyWee contends that Withanawasam "discloses a display device but does not disclose that the display device is 'built-in to and integrated' with a pointing device." Reply RMTA 10 (citing Ex. 1049 ¶¶ 11–12). Rather, CyWee argues that Withanawasam's display device "is merely identified as a component in a block diagram . . . ; it is not described as 'built-in' to a pointing device. Indeed, Withanawasam makes no mention of a pointing device." *Id.* (citing Ex. 1049 ¶¶ 11–12, Fig. 1).

We find LGE's argument persuasive. As LGE notes, CyWee argued in its original Motion to Amend, based on supporting testimony of Professor LaViola, that a person of ordinary skill in the art "would understand that a smartphone is a device with a 'built-in display . . . integrated on the

housing.'" Paper 19, 11 (citing Ex. 2015 ¶ 43). Withanawasam teaches that its disclosed device can be "a smart phone[] or any similar mobile device configured to aid a user in navigation and applications requiring orientation information." Ex. 1049 ¶ 11. This is sufficient to disclose a built-in display that is integrated on the housing.

As the Board found in *Google v. CyWee*, we also find that in Withanawasam's device as modified by Bachmann, the "resultant angles of the resulting deviation in the spatial pointer reference frame" would be "translated to a movement pattern in the display reference frame." *See* IPR2018-01258, Paper 86, at 84–85. Thus, we determine that LGE has shown that the combination of Withanawasam and Bachmann teaches limitation 20(i).

In light of the above considerations, we conclude that LGE shows, by a preponderance of the evidence, that proposed substitute claim 20 is unpatentable under 35 U.S.C. § 103(a) as obvious over Withanawasam in view of Bachmann.

(d) Proposed Substitute Claim 21 (Withanawasam and Bachman)

Proposed substitute claim 21, intended to replace original claim 5, requires that the "data transmitting unit" is attached to the PCB "and transmits said first and second signal of the six-axis motion sensor module to the computing processor via electronic connections on the PCB." RMTA, App'x A, 2. The claim also adds the limitation "wherein the 3D pointing device is a cellular phone." *Id.*

LGE argues that "Withanawasam teaches that its device could be a 'smartphone,' which is a 'cellular phone.' Thus, the new feature of claim 21

is disclosed by the Withanawasam–Bachman combination." Opp. RMTA 22 (citing Ex. 1051 ¶ 65). CyWee does not specifically respond to this argument. *See* Reply RMTA 10–11.

We find LGE's argument persuasive. We also credit Professor Michalson's testimony that Withanawasam's single PCB would include "suitable interfaces and interconnects" that would "form a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting said first and second signal sets thereof." Ex. 1051 ¶ 62 (quoting Ex. 1049 ¶ 11). Thus, we conclude that LGE shows, by a preponderance of the evidence, that proposed substitute claim 21 is unpatentable under 35 U.S.C. § 103(a) as obvious over Withanawasam in view of Bachmann.

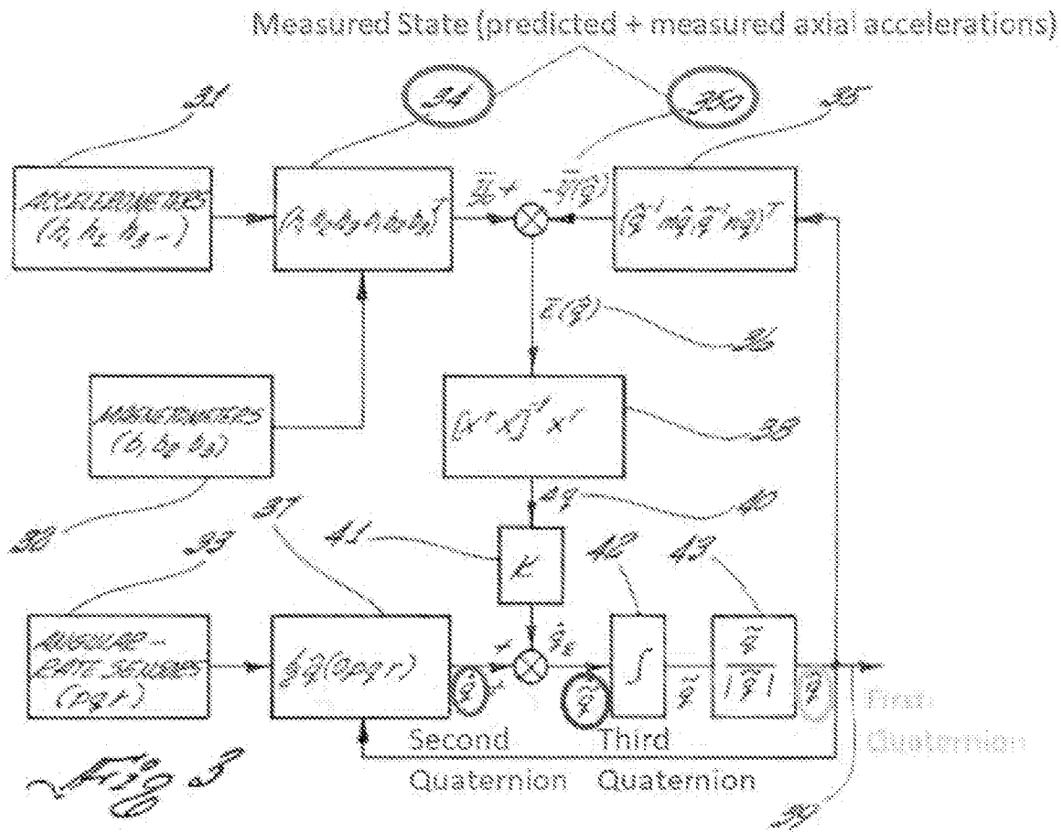
(e) Proposed Substitute Claim 22 (Withanawasam and Bachman)

Proposed substitute claim 22 is essentially the same as original claim 14 except for some additional limitations in the preamble, and it remains unchanged from the proposed substitute claim 22 that CyWee submitted as part of its original Motion to Amend. *Compare* RMTA App'x A, 2–3, *with* Ex. 1001, 21:8–45, *and* MTA App'x A, 2–3.

The preamble of proposed substitute claim 22 describes hardware essentially the same as that recited in limitations 20(a)–(b), (c), and (i), including the requirements that the sensor module is attached to a single PCB, that there is a single housing, and that there is a built-in display device integrated with the 3D pointing device and associated with a display reference frame. *See* RMTA App'x A, 2.

LGE argues that proposed substitute claim 22 "recites limitations that are generally coextensive in scope with those in claim 20," and LGE relies on the testimony of Mr. Andrews supporting ZTE's Opposition to CyWee's Motion to Amend. Opp. MTA 22. According to LGE, "Mr. Andrews has already explained how Bachmann also discloses any differences between [proposed substitute claims 22 and 20]." *Id.* (citing Ex. 1030 ¶¶ 102–10). We discuss ZTE's position as to original claims 14 and 19 above, based on Mr. Andrews's testimony, and we find it persuasive. *See supra* part IV.C.5(n). As we understand this testimony, Mr. Andrews identifies the first and third quaternions as estimated orientation quaternions $\hat{q}$ taken at times $T-1$ and T, respectively. *See* Ex. 1030 ¶ 102.

According to LGE, Professor Michalson agrees with Mr. Andrews's testimony *Id.* (citing Ex. 1051 ¶¶ 66–68). However, Professor Michalson also offers a slightly modified interpretation of Bachmann's Figure 3, which he illustrated in an annotated version of Figure 3, reproduced below:



Ex. 1051 ¶ 66. Professor Michalson's annotated version of Bachmann's Figure 3, above, includes the label "Measured State (predicted + measured axial accelerations)" with lines pointing to boxes 34 and 35a. The figure also identifies what Professor Michalson identifies as the "first," "second," and "third" quaternions. In Professor Michalson's view, the first quaternion, representing the "previous state" recited in limitation 22(a), is the vector $\hat{q}$. Ex. 1051 ¶ 67 (citing Ex. 1030 ¶ 102). He opines that the second quaternion, representing the "current state" recited in limitation 22(b), is the value $\dot{q}$ in Figure 3 box 37. In his view, the third quaternion, representing the "updated state" recited in limitation 22(g), is corrected rate quaternion $\dot{\hat{q}}$.

CyWee does not specifically respond to LGE's arguments regarding proposed substitute claim 22. *See* Reply RMTA 10–11. We note, however,

that Professor Michalson's interpretation of Figure 3 differs from that of Mr. Andrews, in that whereas Mr. Andrews identifies the third quaternion as estimated orientation quaternion $\hat{q}$ taken at time T, Professor Michalson identifies the third quaternion as corrected rate quaternion $\dot{\hat{q}}$.

We do not consider Professor Michalson's testimony to contradict that of Mr. Andrews, because both interpretations of the "updated state" are consistent with the language of original claim 14 and proposed substitute claim 22. Either corrected rate quaternion $\dot{\hat{q}}$ or estimated orientation quaternion $\hat{q}$ may be considered the "updated state" because they both occur in Figure 3 at a point *after* rate quaternion $\dot{q}$ has been updated based on the previous state ($\hat{q}$ at time $T-1$) and the measured state ($\bar{y}_0$ and $\bar{y}(\hat{q})$) via correction factor $\dot{q}_\varepsilon$.

In sum, we find LGE's argument persuasive, and we credit the testimony of Mr. Anderson and Professor Michalson. Thus, we conclude that LGE shows, by a preponderance of the evidence, that proposed substitute claim 22 is unpatentable under 35 U.S.C. § 103(a) as obvious over Withanawasam in view of Bachmann.

3. Obviousness of Proposed Substitute Claims 23 and 24 over Withanawasam, Bachmann, and Bachmann2

LGE contends that proposed substitute claims 23 and 24 are unpatentable under 35 U.S.C. § 103(a) for obviousness over Withanawasam in view of Bachmann and Bachmann2. Opp. RMTA 15–18, 22–23. For the reasons below, we determine that a preponderance of the evidence supports LGE's contention. After providing an overview of Bachmann2, we discuss the evidence as it relates to proposed substitute claims 23 and 24, with

particular emphasis on the differences between these claims and proposed substitute claims 20–22, which we address above.

(a) Overview of Bachmann2

ZTE introduced Bachmann2 in its Opposition to CyWee's original Motion to Amend, and alleged that it was published in 2001 as part of the 2001 IEEE/RSJ International Conference on Intelligent Robots and Systems, in Maui, Hawaii, between October 29 and November 3, 2001. Paper 34, 10 & n.1. According to ZTE, it is prior art under 35 U.S.C. §102(b). *Id.* at 10.

CyWee does not contest that Bachmann2 is prior art to the '438 patent. The paper itself bears indicia that it is a 2001 publication, including an ISBN and copyright line that reads "0-7803-6612-3/01/$10.00©2001 IEEE," appearing to indicate that it was assigned an ISBN number and that it was published in 2001 by the IEEE. Therefore, we conclude that Bachmann2 is a printed publication and is prior art to the '438 patent under § 102(b).

Bachmann2 relates to the MARG sensors described in Bachmann, but replaces Bachmann's "complementary" filter with an extended Kalman filter. Ex. 1032, 2003 ("This paper presents an extended Kalman filter for real-time estimation of rigid body orientation using the newly developed MARG . . . sensors."), 2004 ("This paper follows the same approach as [a paper related to the Bachmann reference], but replaces the complementary filter with a Kalman filter.").

As background, a different paper by CyWee's expert Professor LaViola describes an extended Kalman filter as "a set of mathematical equations which uses an underlying process model to make an estimate of the current state of a system and then corrects the estimate using any available sensor measurement." Ex. 1046, 2435–36; *see also* Ex. 1048,

65:1–5 (Professor LaViola testifying that the extended Kalman filter in his paper "had an underlying process model that describes the relationship between quaternions and angular velocity"); *id.* at 66:4–7 ("[I]n the context of an [extended Kalman filter] you sort of have the state transition which . . . describes how the underlying process model behaves.").

Bachmann2 describes two alternative approaches for using an extended Kalman filter, which share a common process model. *See* Ex. 1032, 2005–06, 2008. This process model is illustrated graphically in Figure 2, reproduced below:

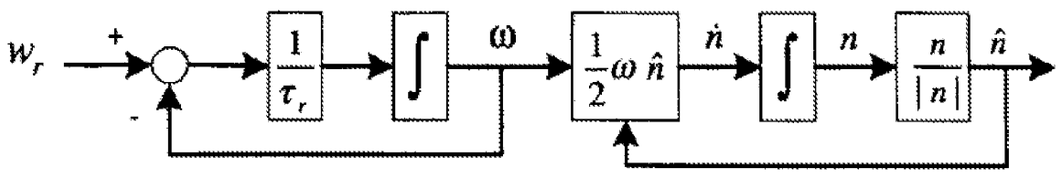


Figure 2. Process Model for Angular Rates and Quaternions.

Figure 2 of Bachmann2, captioned "Process Model for Angular Rates and Quaternions," depicts a process "model of a rigid body for the purpose of estimating its rotational motions." Ex. 1032, 2005. The model has a feedback loop on the left, and another feedback loop on the right. *See id.* at 2004, Fig. 1 (depicting the loop on the left separately). The loop on the left is "a simple first order model for the angular rate" ω defined in terms of roll, pitch, and yaw. *Id.* at 2004–05, Fig. 1. The feedback loop on the right of Figure 2 indicates that angular rate ω is converted to rate quaternion $\dot{n}$, which is integrated and then normalized to form orientation quaternion $\hat{n}$, which is also fed back into the calculation for rate quaternion $\dot{n}$. *See id.* at 2005.

The above process model includes seven state variables: the three angular rates in vector ω representing roll, pitch, and yaw, and the four

quaternion components of normalized orientation quaternion $\hat{n}$. Ex. 1032, 2005–06 (labeling the seven variables as x_1–x_7).

The first of Bachmann2's alternative approaches uses a standard extended Kalman filter "which has seven states (3-dimensional angular rates, and 4-dimensional quaternion), and nine outputs (nine measurements directly from the MARG sensor)." Ex. 1032, 2005. Writing from the perspective of its 2001 publication, Bachmann2 states that this approach was "difficult to implement in real time" because of its complexity, given that "a minimum of fifteen MARG sensors are needed to fully track one avatar, not to mention simultaneous tracking of multiple avatars in a virtual environment." *Id.* at 2005–06.

To overcome this computational complexity, Bachmann2's second approach "uses the Gauss-Newton iteration algorithm to find the best matched quaternion for each measurement from the accelerometers and magnetometers," and the resulting computed quaternion "is taken as part of measurements for the Kalman filter, in addition to the measurements provided by the angular rate sensor." Ex. 1032, 2005. In other words, the second approach fits a quaternion to the measured accelerometer and magnetometer measurement data and uses its four quaternion components as "measurements" in addition to the three angular rate measurements. Thus, the measurement "outputs are exactly the same as the states." *Id.* at 2008.

As a result, the second approach is able to simplify the extended Kalman filter because "the outputs of the Kalman filter are reduced from nine to seven," and "the output equations become linear." Ex. 1032, 2005. "[S]ince part of the state equations is nonlinear," the second approach still uses an extended Kalman filter, but "linearity in the output equations

significantly simplifies the filter design and reduces the computational requirements for real-time implementation." *Id.* at 2008.

(b) Proposed Substitute Claim 23

Proposed substitute claim 23 is intended to replace original claim 15, which depends from claim 14. *See* RMTA App'x A, 3. As with claim 15, proposed substitute claim 23 recites a method that further comprises "outputting the updated state of the six-axis motion sensor module to the previous state of the six-axis motion sensor module." *Compare id.*, *with* Ex. 1001, 21:48–50. Also, "said resultant angles of the resulting deviation includes yaw, pitch and roll angles about each of three orthogonal coordinate axes of the spatial pointer reference frame." *Compare* RMTA App'x A, 3, *with* Ex. 1001, 21:50–53. We addressed these limitations above in the context of whether the Yamashita–Bachmann combination would have rendered original claim 15 obvious, and we found that Bachmann teaches these limitations. *See supra* part IV.C.5(o).

In addition, proposed substitute claim 23 requires that "said angular velocities ω_x, ω_y, ω_z and said second quaternion are represented by at least one Extended Kalman Filter [EKF] equation; and the step of using at least one Jacobian to linearize said measured state." RMTA App'x, 3.

As we discuss above, Bachmann teaches a sensor fusion algorithm that uses Gauss-Newton iteration as a filter to minimize the error between measured and predicted axial accelerations. *See supra* part IV.C.2. LGE contends that a person of ordinary skill in the art "would have been motivated to use *other* filtering embodiments, including extended Kalman filters, with the Withanawasam–Bachman combination, because Bachmann expressly motivates such uses." Opp. RMTA 22 (emphasis added) (citing

Ex. 1007, 9:37–40 ("Alternatively, other filtering embodiments can be employed including, but not limited to . . . Kalman filters."), 17:60–62 ("Also, the inventors contemplate other filtering embodiments including, but not limited to . . . Kalman filters.")); *see also* Paper 34, 20 (ZTE arguing in its Opposition to the original Motion to Amend that "Bachmann discloses using a Gauss-Newton iteration to minimize the error between predicted axial accelerations and the measured axial accelerations," but also teaches Kalman filters as an alternative implementation (citing Ex. 1007, 9:9–45)).

Bachmann itself does not refer to an *extended* Kalman filter, so LGE relies on Bachmann2. *See* Ex. 1051 ¶ 69 (Professor Michalson testifying that "[t]he Bachmann reference . . . describes a linear Kalman filter model, but Bachmann expressly discloses the possibility of 'other filtering embodiments' [such as an extended Kalman filter]" (citing Ex. 1007, 17:60–62)).

ZTE, likewise, relied on Bachmann2 for essentially the same reasons in its Opposition to the original Motion to Amend. *See* Paper 34, 10–14, 20–22. According to ZTE, Bachmann2 "provides a detailed mathematical description of two different approaches to using an extended Kalman Filter to generate an updated state quaternion based on the previous state quaternion." *Id.* at 21.

As LGE elaborates on ZTE's argument, "[i]n its Figure 2, Bachmann2 discloses an EKF equation that includes both angular velocities and a second quaternion (n)." Opp. RMTA 23 (Ex. 1032, 3). According to LGE, proposed substitute claim 23 "do[es] not require any operations performed with the newly[ ]recited EKF equation. Thus, Bachmann2's disclosure of the recited EKF equation is sufficient." *Id.* (Ex. 1051 ¶¶ 69–71). Thus, LGE regards the

process model equation represented in Bachmann2's Figure 2 to be an extended Kalman filter equation as recited in proposed substitute claim 23.

Regarding the requirement in proposed substitute claim 23 that the method perform "the step of using at least one Jacobian to linearize said measured state," LGE states that "Bachmann2 also discloses use of a Jacobian to linearize a measured state." Opp. RMTA 23 (citing Ex. 1032, 5).

CyWee does not specifically contest LGE's arguments regarding claim 23, or ZTE's prior arguments on which LGE relies. We find those arguments persuasive, both (1) as to using at least one extended Kalman filter equation, and (2) as to using a Jacobian to linearize the measured state. We discuss both points below.

(1) Representing Angular Velocities and the Second Quaternion by an Extended Kalman Filter Equation

First, we find persuasive LGE's argument that the process model in Bachmann2's Figure 2 represents an extended Kalman filter equation representing the angular velocities and the second quaternion.

That the extended Kalman filter equations include a process model is consistent with the teachings in the '438 patent. In deposition, Professor LaViola testified that the "standard extended Kalman filter equations" include "the process model and the appropriate covariance matrix and . . . the measurement model and the appropriate covariance matrix for that. And in each case you have the Jacobian." Ex. 1048, 102:10–21. He also testified that in the '438 patent, "[t]he process model is defined in equation 5." *Id.* at 103:20–21. Consistent with this, CyWee argues in its Revised Motion to Amend that in the '438 patent, "a [person of ordinary skill] viewing the

exemplary equations (5) through (10) of the comparison method utilized by the invention would know that they are EKF equations." RMTA 12; *see also* Paper 19, 12 (same); Ex. 2021 ¶ 46 ("I explained in detail at my deposition that 'the equations [including equation 5] in ['the 438 patent's] specification are extended Kalman filter equations." (first alteration in original)).

Specifically as it relates to proposed substitute claim 23, Professor LaViola testified that process model equations 1 and 5 are the only extended Kalman filter equations in the '438 patent that represent angular velocities and the second quaternion. Ex. 1048, 237:6–16. Thus, the record is clear that a person of ordinary skill in the art would have understood a process model equation such as equation 1 or 5 to be "at least one Extended Kalman Filter equation" that represents "said angular velocities $\omega_x, \omega_y, \omega_z$ and said second quaternion" as recited in proposed substitute claim 23. RMTA App'x A, 3.

The evidence of record shows that Bachmann2's process model, shown graphically in Bachmann2's Figure 2, is such an extended Kalman filter equation. Like equations 1 and 5 of the '438 patent, Bachmann2's process model includes angular rate ω of the rigid body, which is defined by angular velocities around the x, y, and z axes. *See* Ex. 1032, 2004. Also like equations 1 and 5, Bachmann2's process model includes "parameters for characterizing orientation, in this case, quaternion n" which corresponds to the "second quaternion" in proposed substitute claim 23. *Id.* at 2004–05. Thus, we agree with LGE that the process model in Bachmann2 includes angular velocities and a "second quaternion" representing the current state of the rigid body.

Because of the overall similarity between the algorithms in Bachmann and Bachmann2, and because Bachmann suggests the use of Kalman filters,

we credit Professor Michalson's testimony that "implementation of Bachmann2 [in the combination of Withanawasam–Bachmann] is nothing more than a routine engineering task that falls well[ ]within the capabilities of a [person of ordinary skill in the art]." Ex. 1051 ¶ 69. We also find persuasive Professor Michalson's testimony that a person of ordinary skill in the art would have looked to an extended Kalman filter precisely because Bachmann2's process model is nonlinear. *See id.*

Thus, based on the record before us, we find that a person of ordinary skill in the art would have had the motivation and technical ability to modify the Withanawasam–Bachmann combination by incorporating an extended Kalman filter based on the teachings of Bachmann2.

(2) Using a Jacobian to Linearize the Measured State

We agree with LGE that Bachmann2 describes, at least as part of its "second approach," the use of a Jacobian to linearize a measured state. *See* Opp. RMTA 23 (citing Ex. 1032, 2007).[48] Like Bachmann, Bachmann2 teaches using a Gauss-Newton algorithm to minimize an error function. *See* Ex. 1032, 2006–08. Bachmann2 does this to minimize the error between y_0 (comprising the "measured" components of gravity and the earth's magnetic field derived from accelerometers and magnetometers) and y_1 (comprising

[48] Professor LaViola also testifies that a standard extended Kalman filter includes a measurement model and "the Jacobian, which linearizes the nonlinear function that is being represented by the underlying model." Ex. 1048, 102:10–24. Thus his testimony, which we find persuasive, suggests that even without an explicit disclosure of a Jacobian, Bachmann2's use of a standard extended Kalman filter would necessarily include at least one Jacobian to linearize the measured state.

"known" components of gravity and the earth's magnetic field, which are constant in a given geographic area). *Id.* at 2007. Bachmann2 explains that the Gauss-Newton algorithm involves using a Jacobian matrix (J in equation 23). *Id.*[49] Thus, we find that LGE has shown that Bachmann2 teaches using at least one Jacobian to linearize the measured state in the combination of Withanawasam and Bachmann.

In sum, we find that a person of ordinary skill in the art would have had reason combine the teachings of Withanawasam, Bachmann, and Bachmann2 such that "said angular velocities ω_x, ω_y, ω_z and said second quaternion are represented by at least one Extended Kalman Filter equation; and the step of using at least one Jacobian to linearize said measured state," as recited in proposed substitute claim 23. Thus, we conclude that LGE has shown, by a preponderance of the evidence, that proposed substitute claim 23 is unpatentable under 35 U.S.C. § 103(a) as obvious over Withanawasam in view of Bachmann and Bachmann2.

(c) Proposed Substitute Claim 24

Proposed substitute claim 24 is intended to replace independent original claim 19. *See* RMTA App'x A, 3. Claim 19 is virtually identical to claim 14, but CyWee intends the proposed claim 24 amendments to "contain[] all of the clarifications and limitations of the preceding Proposed Contingent Claims." RMTA 2. These proposed amendments are found in the preamble 24(Pre) and limitations 24(d) and 24(h). *See id.* App'x A, 3–5. This

[49] Like Bachmann2, Bachmann uses a Gauss-Newton algorithm to minimize the error between vectors $\bar{y}_0$ and $\bar{y}(\hat{q})$ in box 38 of Bachmann's Figure 3. *See* Ex. 1007, 9:9–43, Fig. 3. However, Bachmann does not explicitly state that this iteration involves using a Jacobian.

includes the requirement of "utilizing at least one Extended Kalman Filter equation," that the motion sensor module is "attached to a single PCB," that "the 3D pointing device comprises a cellular phone with a display device built-in to and integrated with the 3D pointing device and associated with a display reference frame," that "said measured angular velocities ω_x, ω_y, ω_z and said second quaternion are represented by at least one Extended Kalman Filter equation; and at least one Jacobian is used to linearize said measured state," and a step of "translating said resultant angles of the resulting deviation to a movement pattern in the display reference frame." *Id.* at 3–5.

We discuss each of these limitations in the preceding sections as they appear in proposed substitute claims 20–23, and we determine that a person of ordinary skill in the art would have had reason to modify Withanawasam to practice each of these limitations, based on the teachings of Bachman and Bachamann2. *See supra* parts V.D.2, V.D.3(b).

Thus, we conclude that LGE shows, by a preponderance of the evidence, that proposed substitute claim 24 is unpatentable under 35 U.S.C. § 103(a) as obvious over Withanawasam in view of Bachmann and Bachmann2.

4. Obviousness of Proposed Substitute Claims 20–24 over Yamamoto, Bachmann, and Bachmann2

Alternatively to the proposed combinations based on Withanawasam, LGE argues that proposed substitute claims 20–22 are unpatentable under 35 U.S.C. § 103(a) for obviousness over Yamamoto in view of Bachmann, and that proposed claims 23 and 24 are unpatentable over as obvious over Yamamoto in view of Bachmann and Bachmann2. Opp. RMTA 23.

CyWee argues that "LG[E] makes no attempt to show that *Yamamoto* encloses all the components that are recited in the claims in a single housing," or that Yamamoto meets "other limitations recited in claims 20–24," including 20(c)–(i), 21, 22(Pre)–22(g), and 23. Reply RMTA 12.

Responding to this in the Sur-Reply, LGE argues that "[t]he Opposition . . . relies on Dr. Michalson's analysis in paragraphs 72–83 of Ex. 1051, which is briefly summarized here [in the Sur-Reply]." Sur-Reply RMTA 10–11.

We agree with CyWee that LGE's analysis in its Opposition to the Revised Motion to Amend is insufficiently specific. It spans less than a page, and LGE does not conduct a claim-by-claim analysis. As CyWee correctly points out, LGE also omits discussion of several claim limitations. LGE's reliance on twelve paragraphs of Professor Michalson's expert report is also improper under our rules. *See* 37 C.F.R. § 42.6(a)(3) (2019) ("Arguments must not be incorporated by reference from one document into another document."). LGE's attempt to summarize Professor Michalson's testimony in its Sur-Reply comes too late, given that CyWee was not afforded an opportunity to respond.

Thus, we determine that LGE has not met its burden to provide specific arguments for why it contends the proposed substitute claims are unpatentable over Yamamoto in view of Bachmann and Bachmann2. *See Magnum Oil Tools*, 829 F.3d at 1380 ("To satisfy its burden of proving obviousness, a petitioner cannot employ mere conclusory statements. The petitioner must instead articulate specific reasoning, based on evidence of record, to support the legal conclusion of obviousness." (citing *KSR*, 550 U.S. 398 at 418)).

E. CONCLUSION

Because proposed substitute claims 21 and 24 contain new matter, and because LGE sufficiently shows that proposed substitute claims 20–24 are unpatentable for obviousness over the combination of Withanawasam, Bachmann, and Bachmann2, we deny CyWee's Revised Motion to Amend.

VI. CONCLUSION

For the reasons above, ZTE has shown by a preponderance of the evidence that the challenged claims of the '438 patent are unpatentable, as summarized in the following table:

Claims	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not shown Unpatentable
1, 4, 5, 14–17, 19	103(a)	Yamashita, Bachmann	1, 4, 5, 14–17, 19	
1, 4, 5, 14–17, 19	103(a)	Nasiri, Sachs, Song		1, 4, 5, 14–17, 19
Overall Outcome			1, 4, 5, 14–17, 19	

The table below summarizes our conclusions as to CyWee's Revised Motion to Amend the claims:[50]

Motion to Amend Outcome	Claim(s)
Original Claims Cancelled by Amendment	
Substitute Claims Proposed in the Amendment	20–24
Substitute Claims: Motion to Amend Granted	
Substitute Claims: Motion to Amend Denied	20–24
Substitute Claims: Not Reached	

[50] Should CyWee wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw CyWee's attention to the April 2019 *Notice Regarding*

VII. ORDER

In consideration of the foregoing, it is

ORDERED that claims 1, 4, 5, 14–17, 19 of the '438 patent are unpatentable;

FURTHER ORDERED that CyWee's Revised Motion to Amend (Paper 38) is *denied*;

FURTHER ORDERED that CyWee's Motion to Exclude (Paper 66) is *denied*;

FURTHER ORDERED that CyWee's objections to LGE's demonstrative exhibits (Paper 80) are *overruled*;

FURTHER ORDERED that LGE's objections to CyWee's (Paper 78) demonstrative exhibits are *overruled*; and

FURTHER ORDERED that parties to this proceeding seeking judicial review of our decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding. See 84 Fed. Reg. 16,654 (Apr. 22, 2019). If CyWee chooses to file a reissue application or a request for reexamination of the challenged patent, we remind CyWee of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. § 42.8(a)(3), (b)(2).

IPR2019-00143
Patent 8,441,438 B2

For PETITIONER:

Dion Bregman
Alexander Stein
Collin Park
Andrew Devkar
Jeremy Peterson
Adam Brooke
Howard Wisnia
Steve Moore
dion.bregman@morganlewis.com
alexander.stein@morganlewis.com
collin.park@morganlewis.com
andrew.devkar@morganlewis.com
jeremy.peterson@pvuslaw.com
adam.brooke@morganlewis.com
howard@wisnialaw.com
stevemoore@zhonglun.com

For PATENT OWNER:

Jay Kesan
jay@jaykesan.com

Doc Code: A.NE.AFCP
Document Description: After Final Consideration Pilot Program Request

PTO/SB/434 (12-20)

CERTIFICATION AND REQUEST FOR CONSIDERATION UNDER THE AFTER FINAL CONSIDERATION PILOT PROGRAM 2.0

Practitioner Docket No.:	Application No.:	Filing Date:
250303-1022	16/953,771	November 20, 2020
First Named Inventor:	**Title:**	
Shun-Nan LIOU, et al.	Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof	

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	Practitioner Registration No.
/M.PaulQualey,Jr./	4/14/2022	43,024
Name (Print/Typed)	**Telephone Number**	
M. Paul Qualey, Jr.	678-483-8899	

***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.

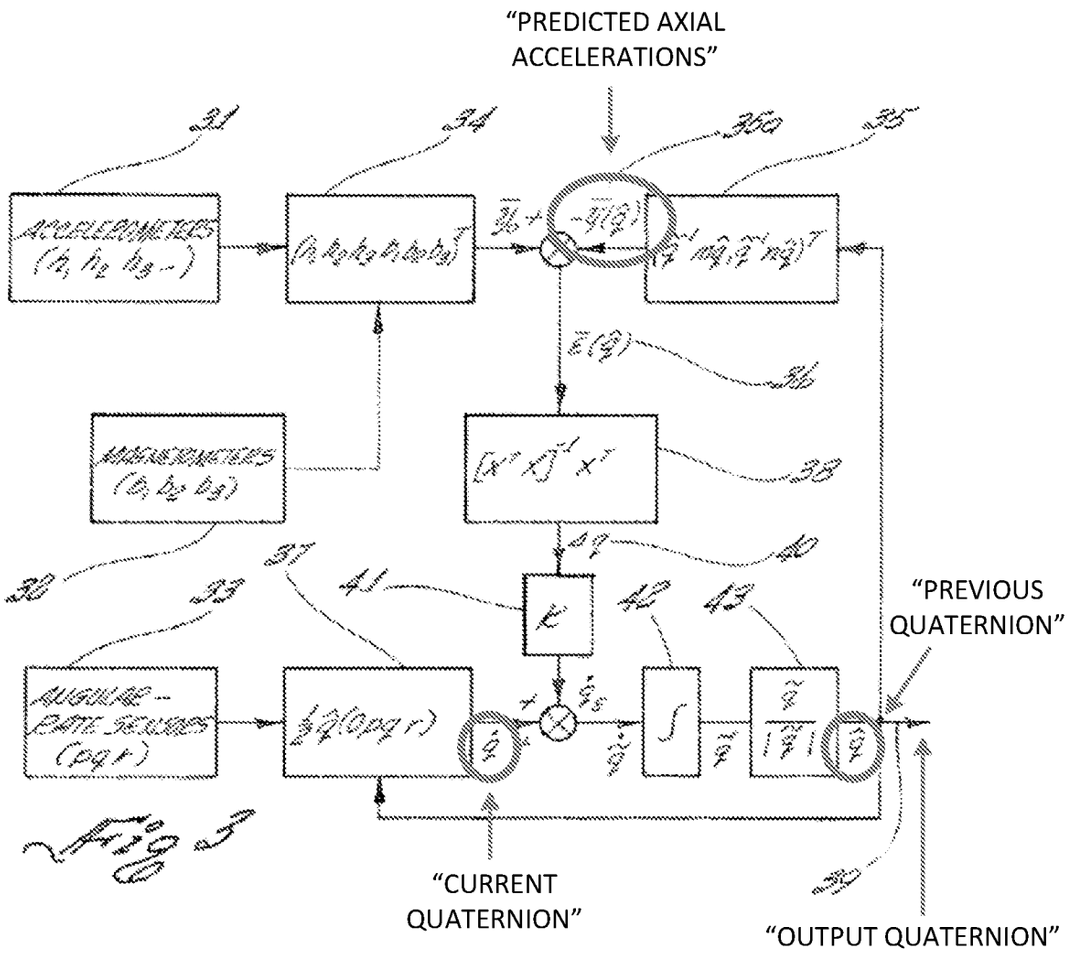
Privacy Act Statement

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.

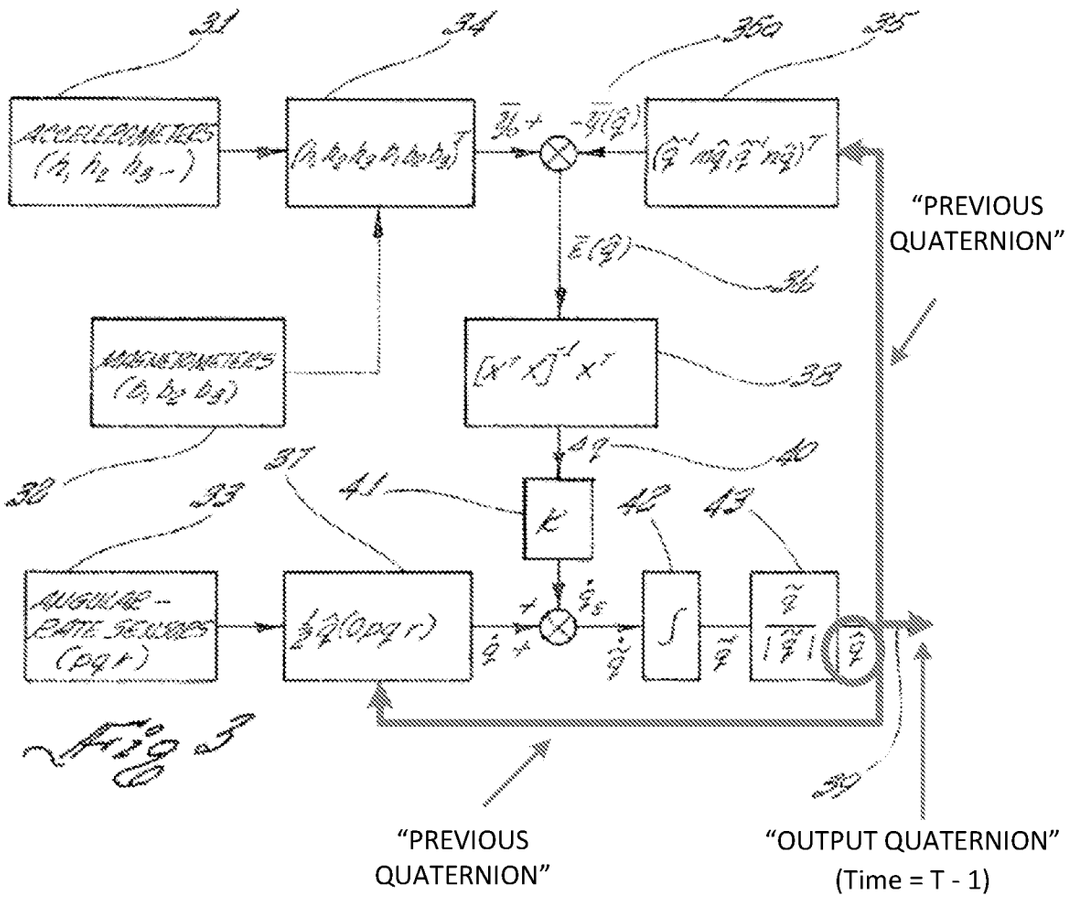
The information provided by you in this form will be subject to the following routine uses:

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.

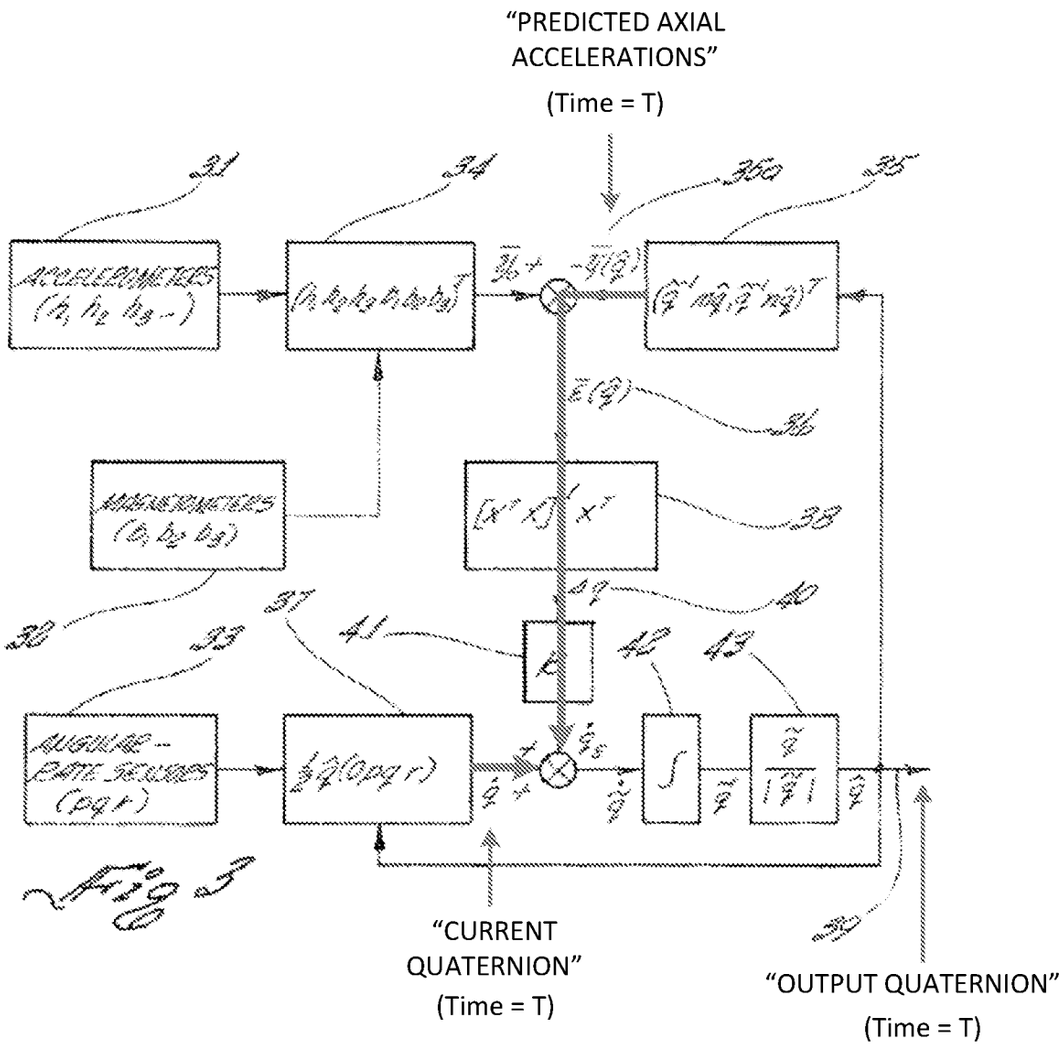
Annotated Figure A



Annotated Figure B



Annotated Figure C



Electronic Acknowledgement Receipt	
EFS ID:	45473332
Application Number:	16953771
International Application Number:	
Confirmation Number:	1038
Title of Invention:	ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF
First Named Inventor/Applicant Name:	Shun-Nan LIOU
Customer Number:	109673
Filer:	Michael P. Qualey/Brooke French
Filer Authorized By:	Michael P. Qualey
Attorney Docket Number:	250303-1022
Receipt Date:	14-APR-2022
Filing Date:	20-NOV-2020
Time Stamp:	11:44:26
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	00960734.PDF	229925 38ef9a333858b9b5ec7e501eccefaf963ef88dda	no	2

Warnings:

Information:					
2	Response After Final Action	00966433.PDF	217423 a6cbb4398e1fb0f45944d9fad4c2f69b1cfae109	no	17
Warnings:					
Information:					
3	Drawings-only black and white line drawings	00966165.PDF	212130 543f9fef318794f1c9016442dbcc89fb9128a1ef	no	3
Warnings:					
Information:					
		Total Files Size (in bytes):	659478		

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.

<u>New Applications Under 35 U.S.C. 111</u>
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.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
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.
<u>New International Application Filed with the USPTO as a Receiving Office</u>
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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:

Shun-Nan LIOU, et al.

Serial No.: 16/953,771

Filed: November 20, 2020

For: Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof

Confirmation No.: 1038

Group Art Unit: 2625

Examiner: Earles, Bryan E.

Docket No.: 250303-1022

AMENDMENT AND RESPONSE TO FINAL OFFICE ACTION

Mail Stop: AF
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Director:

The outstanding Final Office Action mailed 21 March 2022, has been carefully considered. In response thereto, please enter the following amendments and remarks pursuant to the After Final Consideration Pilot Program 2.0. Reconsideration and allowance of the application and presently pending claims, as amended, are respectfully requested.

AMENDMENTS

In the Claims

1. (Currently Amended) An electronic device subject to movements and rotations in a spatial reference frame, comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by performing the following in sequence:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting [[the]] measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T;

obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;

comparing the predicted axial accelerations with measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

2. (Original) The electronic device of claim 1, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame.

3. (Original) The electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

4. (Original) The electronic device of claim 1, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

5. (Original) The electronic device of claim 1, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

6. (Canceled)

7. (Original) The electronic device of claim 1, wherein the content is visual content.

8. (Original) The electronic device of claim 7, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

9. (Original) The electronic device of claim 8, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

10. (Original) The electronic device of claim 1, wherein:

the motion sensor module further comprises a magnetometer having magnetometer circuitry configured to generate measured magnetisms; and

in calculating the resulting deviation, the computing processor is further configured to:

convert the measured magnetisms corresponding to time T to a measured yaw angle and convert the angular velocities corresponding to time T to a predicted yaw angle;

compare the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtain the updated quaternion based on the second comparison result.

11. (Original) The electronic device of claim 10, wherein:

the measured yaw is based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

12. (Original) The electronic device of claim 10, wherein, in calculating the resulting deviation, the computing processor is further configured to:

obtain a first updated quaternion based on the current quaternion and the first comparison result; and

obtain a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

13. (Original) The electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtain the updated quaternion in response to determining that the compensation is needed.

14. (Original) The electronic device of claim 13, wherein, in calculating the resulting deviation, the computing processor is further configured to utilize the first data association model to determine whether compensation is needed to obtain the updated quaternion based on

whether the first comparison result is a first predetermined value or within a first predetermined range.

15. (Currently Amended) A method for determining movements and rotations in a spatial reference frame, comprising:

generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;

calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by performing the following in sequence:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting [[the]] measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T;

obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;

comparing the predicted axial accelerations with measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion; and

providing content based on the resulting deviation in the spatial reference frame.

16. (Original) The method of claim 15, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of an electronic device in a spatial reference frame.

17. (Original) The method of claim 15, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

18. (Original) The method of claim 15, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

19. (Original) The method of claim 15, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

20. (Canceled)

21. (Original) The method of claim 15, wherein the content is visual content.

22. (Original) The method of claim 21, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

23. (Original) The method of claim 22, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

24. (Original) The method of claim 15, wherein:

the method further comprises generating, with a magnetometer having magnetometer circuitry, measured magnetism; and

calculating the resulting deviation further comprises:

converting the measured magnetisms corresponding to time T to a measured yaw angle and converting the angular velocities corresponding to time T to a predicted yaw angle;

comparing the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtaining the updated quaternion based on the second comparison result.

25. (Original) The method of claim 24, wherein:

the measured yaw is calculated and obtained based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

26. (Original) The method of claim 24, wherein calculating the resulting deviation further comprises:

obtaining a first updated quaternion based on the current quaternion and the first comparison result; and

obtaining a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

27. (Original) The method of claim 15, wherein calculating the resulting deviation further comprises:

utilizing a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtaining the updated quaternion in response to determining that the compensation is needed.

28. (Original) The method of claim 27, wherein calculating the resulting deviation further comprises utilizing the first data association model to determine whether compensation is needed

to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range.

REMARKS

The Examiner is thanked for the thorough examination of the present application. The Office Action, however, tentatively rejected claims 1-5, 7-19, and 21-28. In response, Applicant respectfully submits the foregoing amendments, in which claims 1 and 15 are amended. Reconsideration of this application, as amended, is respectfully requested.

Claim Rejections - 35 USC § 103

The Office Action indicates that claims 1-5, 7-19, and 21-28 are rejected under 35 U.S.C. 103 as allegedly being unpatentable over Yamashita, et al. (U.S. 8,267,785, hereinafter "Yamashita") in view of Bachmann, et al. (U.S. 7,089,148, hereinafter, "Bachmann"). Applicant respectfully traverses the rejection for at least the reasons described below.

Independent Claim 1 is Allowable

Claim 1, as amended, recites:

> 1. An electronic device subject to movements and rotations in a spatial reference frame, comprising:
>
> a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and
>
> a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame ***by performing the following in sequence***:
>
> ***providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;***
>
> ***converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T;***
>
> ***obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;***

> comparing the predicted axial accelerations with measured axial accelerations corresponding to time T to obtain a first comparison result;
>
> obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;
>
> using the updated quaternion as a next occurrence of the previous quaternion; and
>
> providing the resulting deviation based on the updated quaternion;
>
> wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

(Emphasis Added).

Applicant respectfully asserts that the cited art is legally deficient for rendering claim 1 unpatentable. In particular, the cited art (either individually or in combination) does teach or reasonably suggest at least the features emphasized above in claim 1.

In relying on the cited art, the Office references the Terminal Decision of IPR 2019-00143, which involves U.S. 8,441,438 and, in particular, the discussion on pages 70-72 related to limitation 1(m). Applicant respectfully notes that limitation 1(m) recites "an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set". That claim language, however, is not recited in the claims currently under examination. Applicant will now set forth several distinguishing aspects of the claims currently under examination to highlight the inapplicability of the findings of the Terminal Decision as well as the teachings of the cited art.

In this regard, the Office Action set forth (at page 4) the following correlations between the features recited in claim 1 and the disclosure of Bachmann:

Claim feature	**Bachmann**
a previous quaternion corresponding to time T-1	"(Bachmann: Fig. 3, the previous quaternion corresponds to the prior orientation output quaternion at 39)"
a current quaternion corresponding to time T	"(Bachmann: Fig. 3, the angular rates at box 33 are converted at box 37 to a rate quaternion)"
predicted axial accelerations corresponding	"(Bachmann: Fig. 3, computed measurement

to time T	vector [symbols omitted] (box 35a) is the predicted axial acceleration. . .)"

These features are shown in Annotated Figure A (attached hereto), which is an annotated version of FIG. 3 of Bachmann.

The Office further explains the contentions as follows:

> obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;
>
> (Bachmann: Fig. 3, computed measurement vector $\overline{y}(\hat{q})$ (box 35a) is the predicted axial acceleration and magnetic orientation quaternion based on the measured angular velocities; rate quaternion $\dot{q}$ is the "current quaternion" representing the "current state"; $\overline{yo}\ (\hat{q})$ represents the current measured values for these quantities, and $\overline{y}(\hat{q})$ represents the same quantities derived from the prior predicted state);

The Office also provides the following at page 12 of the Office Action:

> Based on the Termination Decision (Attached), at pages 70-72, the limitation, "obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion" is obvious over the combination of Yamashita as modified by Bachmann. Bachmann discloses that the computed measurement vector $\overline{y}(\hat{q})$ (box 35a) as the predicted axial acceleration and magnetic orientation quaternion based on the measured angular velocities; rate quaternion $\dot{q}$ is the "current quaternion" representing the "current state"; $\overline{yo}\ (\hat{q})$ represents the current measured values for these quantities, and $\overline{y}(\hat{q})$ represents the same quantities derived from the prior predicted state. As such, the rejection of claims 1-5, 7-19 and 21-28 as being unpatentable over the combination of Yamashita as modified by Bachmann is maintained.

Applicant respectfully disagrees with the correlations between the disclosure of Bachmann and the features recited in claim 1. In particular, the recited feature of "obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion" requires that "predicted axial accelerations corresponding to time T" be based on both "the measured angular velocities corresponding to time T" and "the current quaternion" (which also corresponds to time T). Stated differently, each of "the predicted axial accelerations", "the measured angular velocities" and "the current quaternion" recited in claim 1 are manifest in the same cycle – that is, each corresponds to time T. These relationships are not disclosed or suggested in Bachmann and the other references (either individually or in combination) are inadequate for remedying these deficiencies.

In Bachmann, it appears that the computed measurement vector of Fig. 3, box 35a (correlated with "predicted axial accelerations" in the Office Action) is associated with a time cycle that leads both the angular rates at box 33 (correlated with "measured angular velocities" in the Office Action) and the rate quaternion at box 37 (correlated with "current quaternion" in the Office Action). That is, the angular rates and the rate quaternion of Bachmann are both associated with a previous time cycle when compared to the computed measurement vector. Of significance, the computed measurement vector (box 35a) is combined with the rate quaternion (box 37) downstream of box 41 and prior to output 39. Therefore, the process flow of Bachmann prevents any "predicted axial accelerations corresponding to time T" from being based on measured angular velocities corresponding to time T (in fact, they are based on measured angular velocities corresponding to time T - 1).

This aspect of Bachmann is shown with reference to Annotated Figures B and C (attached hereto). Notably, Annotated Figure B shows that the "output quaternion" (which is

now the "previous quaternion") is provided to both block 35a to form "predicted axial accelerations" (corresponding to time T) and to block 37 to form "current quaternion" (corresponding to time T). Thereafter, as shown in Annotated Figure C, Bachmann's "predicted axial accelerations" are compared to the "current quaternion". However, the "predicted axial accelerations" of Bachmann are not "based on the measured angular velocities corresponding to time T and the current quaternion" as required by claim 1; the "predicted axial accelerations" of Bachmann are based on measured angular velocities corresponding to time T - 1 and the previous quaternion (which also corresponds to time T – 1).

In order to emphasize the aforementioned distinctions and remove any potential ambiguity, Applicant has amended claim 1 to further recite "performing the following in sequence". Thus, it should be clearly improper to interpret the features recited in claim 1 out of the order in which recited. Based on the above, Applicant respectfully asserts that claim 1 is in condition for allowance.

Independent Claim 15 is Allowable

Claim 15, as amended, recites:

> 15. A method for determining movements and rotations in a spatial reference frame, comprising:
>
> generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;
>
> calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by ***performing the following in sequence***:
>
> ***providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;***
>
> ***converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T;***

> ***obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion;***
>
> comparing the predicted axial accelerations with measured axial accelerations corresponding to time T to obtain a first comparison result;
>
> obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;
>
> using the updated quaternion as a next occurrence of the previous quaternion; and
>
> providing the resulting deviation based on the updated quaternion; and
>
> providing content based on the resulting deviation in the spatial reference frame.

(Emphasis Added).

Applicant respectfully asserts that the cited art is legally deficient for rendering claim 15 unpatentable. In particular, the cited art (either individually or in combination) does teach or reasonably suggest at least the features emphasized above in claim 15 for reasons similar to those discussed in detail with respect to the rejection of claim 1. Therefore, Applicant respectfully asserts that claim 15 is in condition for allowance.

Dependent Claims are Allowable

Applicant respectfully asserts that the pending dependent claims are allowable for incorporating the features of their respective independent claims. Additionally, these claims recite other features that may serve as independent bases for patentability.

CONCLUSION

Favorable reconsideration and allowance of the present application and all pending claims are hereby courteously requested.

Should the Examiner feel that further discussion of the application is conducive to prosecution and allowance thereof, please do not hesitate to contact the undersigned by phone (678-483-8899).

No fee is believed to be due in connection with this submission other than those, which may have already been provided. If, however, any fee is believed to be due, you are hereby authorized to charge any such fee to deposit account No. 50-5954.

Respectfully submitted,

/M.PaulQualey,Jr./

By: _____

M. Paul Qualey, Jr.
Registration No. 43,024

Customer No. 109673

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

109673 7590 05/02/2022

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 550
Atlanta, GA 30339

EXAMINER	
EARLES, BRYAN E	

ART UNIT	PAPER NUMBER
2625	

NOTIFICATION DATE	DELIVERY MODE
05/02/2022	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):

callie.reynolds@mqrlaw.com
dan.mcclure@mqrlaw.com
uspatents@mqrlaw.com

PTOL-90A (Rev. 04/07)

Advisory Action Before the Filing of an Appeal Brief	**Application No.** 16/953,771	**Applicant(s)** LIOU et al.	
	Examiner BRYAN EARLES	**Art Unit** 2625	**AIA (FITF) Status** No

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

THE REPLY FILED 14 April 2022 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

NO NOTICE OF APPEAL FILED

1. ☑ The reply was filed after a final rejection. No Notice of Appeal has been filed. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114 if this is a utility or plant application. Note that RCEs are not permitted in design applications. The reply must be filed within one of the following time periods:
   a) ☐ The period for reply expires ____ months from the mailing date of the final rejection.
   b) ☑ The period for reply expires on: (1) the mailing date of this Advisory Action; or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
   c) ☐ A prior Advisory Action was mailed more than 3 months after the mailing date of the final rejection in response to a first after-final reply filed within 2 months of the mailing date of the final rejection.The current period for reply expires ____ months from the mailing date of *the prior Advisory Action* or SIX MONTHS from the mailing date of the final rejection, whichever is earlier.
   Examiner Note: If box 1 is checked, check either box (a), (b) or (c). ONLY CHECK BOX (b) WHEN THIS ADVISORY ACTION IS THE FIRST RESPONSE TO APPLICANTS FIRST AFTER-FINAL REPLY WHICH WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. ONLY CHECK BOX (c) IN THE LIMITED SITUATION SET FORTH UNDER BOX (c). See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) or (c) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37CFR 41.37(a).

AMENDMENTS

3. ☑ The proposed amendments filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   a) ☑ They raise new issues that would require further consideration and/or search (see NOTE below);
   b) ☐ They raise the issue of new matter (see NOTE below);
   c) ☑ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.
   NOTE: _____ (See 37 CFR 1.116 and 41.33(a)).
4. ☐ The amendments are not in compliance with 37 CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☐ Applicant's reply has overcome the following rejection(s): _____
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☑ For purposes of appeal, the proposed amendment(s):(a) ☑ will not be entered, or (b) ☐ will be entered, and an explanation of how the new or amended claims would be rejected is provided below or appended.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____
9. ☐ The affidavit or other evidence filed after final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
10. ☐ The affidavit or other evidence filed after the date of filing the Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing of good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
11. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

12. ☑ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: See Continuation Sheet.
13. ☐ Note the attached Information *Disclosure Statement*(s). (PTO/SB/08) Paper No(s). _____
14. ☑ Other: PTO-2323 Attached herewith.

STATUS OF CLAIMS

15. The status of the claim(s) is (or will be) as follows:
    Claim(s) allowed:_____.
    Claim(s) objected to:_____.
    Claim(s) rejected:1-5,7-19 and 21-28.
    Claim(s) withdrawn from consideration:_____.

/BRYAN EARLES/ Primary Examiner, Art Unit 2625	

Continuation of REQUEST FOR RECONSIDERATION/OTHER 12. The request for reconsideration has been considered but does NOT place the application in condition for allowance because:

The Applicant is thanked for the amendment dated 14 April 2022. However, if entered, Applicant's proposed claim amendments would newly introduce at least the following limitations:

"performing the following in sequence" into claim 1.

Such limitations if incorporated into present claim language would alter the inventive scope of the claims, requiring additional search and consideration.

By such reasoning, non-entry of the proposed Amendment (14 April 2022) is deemed proper and necessary at this time.

On page 14 of Remarks, Applicant argues, "the process flow of Bachmann prevents any "predicted axial accelerations corresponding to time T" from being based on measured angular velocities corresponding to time T (in fact, the are based on measured angular velocities corresponding to time T-1)."

The Office respectfully disagrees. It is noted that there is no substantive difference between a predicted measurement and a vector described as a computed measurement that is fitted by regression to a set of actual measurements. Bachmann, at Figure 3, discloses y.sub.0 represents the current measured values for both axial accelerations and magnetisms, and computed measurement vector {right arrow over (y)}({ circumflex over (q)}) represents the same quantities derived from the prior predicted state. Furthermore, since the measured angular velocities are known for time T, then it seems reasonable to construe that one of ordinary skill in the art would be able to determine the corresponding axial accelerations at time T by using the rate of change of the measured angular velocities. Therefore, the rejection to claims 1-5, 7-19, and 21-28 are maintained as unpatentable over Yamashita in view of Bachmann.

AFCP 2.0 Decision	Application No.	Applicant(s)	
	16/953,771	LIOU et al.	
	Examiner	Art Unit	AIA (FITF) Status
	BRYAN EARLES	2625	No

This is in response to the After Final Consideration Pilot request filed 14 April 2022.

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.

DO NOT ENTER: /BE/

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:
Shun-Nan LIOU, et al.

Serial No.: 16/953,771

Filed: November 20, 2020

For: Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof

Confirmation No.: 1038

Group Art Unit: 2625

Examiner: Earles, Bryan E.

Docket No.: 250303-1022

AMENDMENT AND RESPONSE TO FINAL OFFICE ACTION

Mail Stop: AF
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Director:

The outstanding Final Office Action mailed 21 March 2022, has been carefully considered. In response thereto, please enter the following amendments and remarks pursuant to the After Final Consideration Pilot Program 2.0. Reconsideration and allowance of the application and presently pending claims, as amended, are respectfully requested.

Doc code: RCEX
Doc description: Request for Continued Examination (RCE)

PTO/SB/30EFS (01-22)
Approved for use through 05/31/2024. OMB 0651-0031
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 contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	16/953,771	Filing Date	2020-11-20	Docket Number (if applicable)	250303-1022	Art Unit	2625
First Named Inventor	Shun-Nan LIOU, et al.			Examiner Name	Earles, Bryan E.		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☐ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 505954

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

Applicant Signature

EFS - Web 2.1.16

Doc code: RCEX
Doc description: Request for Continued Examination (RCE)

PTO/SB/30EFS (01-22)
Approved for use through 05/31/2024. OMB 0651-0031
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 contains a valid OMB control number.

Signature of Registered U.S. Patent Practitioner			
Signature	/M.PaulQualey,Jr./	Date (YYYY-MM-DD)	2022-07-28
Name	M. Paul Qualey, Jr.	Registration Number	43,024

This collection of information is required by 37 CFR 1.114. 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.

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 the Freedom of Information Act requires disclosure of these records.

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 inspections 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.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
16/953,771	**07/28/2022 04:52:06 PM ET**	**250303-1022**

Title of Invention

ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1038	FILED BY	Brooke French
PATENT CENTER #	60821968	FILING DATE	11/20/2020
CUSTOMER #	109673	FIRST NAMED INVENTOR	Shun-Nan LIOU
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Michael Qualey

Documents

TOTAL DOCUMENTS: 3

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
00996265.PDF	2	Extension of Time	163 KB
00996312.PDF	17	Amendment Submitted/Entered with Filing of Continued Prosecution Application (CPA)/Request for Continued Examination(RCE)	150 KB
00996319.PDF	3	Request for Continued Examination (RCE)	1628 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
00996265.PDF	2D9AE408126C6CB819636A7FD9A56FE38D2631AE9A4DEE6D C8C7A7AEA80766086F184150CAFAD6DAFA4EE7889B0E05C8 8D9690A684D67F799517B893335874F3
00996312.PDF	BE35F35B0BDB3D0620702C7DA4DA0F28D0FCAE5B5C82A7E5 3564BBFCD55EE3B80B2490B53BF655C9B886C151D117ECC7 E13EFEB25229F3F7CD7A8D3C29115E9A
00996319.PDF	CC73ABB4C66275A672380193D12584F7E5FB74C3BE165F0459 C43AC99447499DCA1C4B08CB8D5D29AF28B4F591357639A2C D80DA778642AEC4C7B563629F556D

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 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.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
16/953,771	07/28/2022 04:52:06 PM ET	250303-1022

Title of Invention

ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1038	FILED BY	Brooke French
PATENT CENTER #	60821968	AUTHORIZED BY	Michael Qualey
CUSTOMER #	109673	FILING DATE	11/20/2020
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Shun-Nan LIOU

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 1007	E20227RG52411443	Brooke French

PRE-AUTHORIZED ACCOUNT	PRE-AUTHORIZED CATEGORY
505954	37 CFR 1.16 (National application filing, search, and examination fees); 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)

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
2252	EXTENSION FOR RESPONSE WITHIN SECOND MONTH -	320.00	1	320.00
2801	REQUEST FOR CONTINUED EXAMINATION (RCE) - 1ST REQUEST (SEE 37 CFR 1.114)	680.00	1	680.00
			TOTAL AMOUNT:	$1,000.00

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 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.

PTO/AIA/22 (10-20)
Approved for use through 11/30/2020. OMB 0651-0031
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.

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)	Docket Number (Optional) 250303-1022
Application Number 16/953,771	Filed November 20, 2020
For ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	
Art Unit 2625	Examiner Earles, Bryan E.

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))	$220	$110	$55	$
☑	Two months (37 CFR 1.17(a)(2))	$640	$320	$160	$ 320.00
☐	Three months (37 CFR 1.17(a)(3))	$1,480	$740	$370	$
☐	Four months (37 CFR 1.17(a)(4))	$2,320	$1,160	$580	$
☐	Five months (37 CFR 1.17(a)(5))	$3,160	$1,580	$790	$

☐ 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 50-5954.

☑ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 43,024.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/M.PaulQualey,Jr./ — Signature
7/28/2022 — Date
M. Paul Qualey, Jr. — Typed or printed name
678-483-8899 — 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: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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

First Named Inventor:

Shun-Nan LIOU, et al.

Serial No.: 16/953,771

Filed: November 20, 2020

For: Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof

Confirmation No.: 1038

Group Art Unit: 2625

Examiner: Earles, Bryan E.

Docket No.: 250303-1022

REQUEST FOR CONTINUED EXAMINATION

Mail Stop: RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Director:

The outstanding Final Office Action mailed 21 March 2022 and subsequent Advisory Action have been carefully considered. In response thereto, please enter the following amendments and remarks pursuant to this Request for Continued Examination. Reconsideration and allowance of the application and presently pending claims, as amended, are respectfully requested.

AMENDMENTS

In the Claims

1. (Currently Amended) An electronic device subject to movements and rotations in a spatial reference frame, comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by performing the following in sequence:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T;

converting [[the]] measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T;

converting variables of the current quaternion into ~~obtaining~~ predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device ~~based on the measured angular velocities corresponding to time T and the current quaternion~~;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

2. (Original) The electronic device of claim 1, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame.

3. (Original) The electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

4. (Original) The electronic device of claim 1, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

5. (Original) The electronic device of claim 1, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

6. (Canceled)

7. (Original) The electronic device of claim 1, wherein the content is visual content.

8. (Original) The electronic device of claim 7, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

9. (Original) The electronic device of claim 8, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

10. (Original) The electronic device of claim 1, wherein:

the motion sensor module further comprises a magnetometer having magnetometer circuitry configured to generate measured magnetisms; and

in calculating the resulting deviation, the computing processor is further configured to:

convert the measured magnetisms corresponding to time T to a measured yaw angle and convert the angular velocities corresponding to time T to a predicted yaw angle;

compare the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtain the updated quaternion based on the second comparison result.

11. (Original) The electronic device of claim 10, wherein:

the measured yaw is based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

12. (Original) The electronic device of claim 10, wherein, in calculating the resulting deviation, the computing processor is further configured to:

obtain a first updated quaternion based on the current quaternion and the first comparison result; and

obtain a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

13. (Original) The electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtain the updated quaternion in response to determining that the compensation is needed.

14. (Original) The electronic device of claim 13, wherein, in calculating the resulting deviation, the computing processor is further configured to utilize the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range.

15. (Currently Amended) A method for determining movements and rotations in a spatial reference frame, comprising:

generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;

calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by performing the following in sequence:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T;

converting [[the]] measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T;

converting variables of the current quaternion into ~~obtaining~~ predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device ~~based on the measured angular velocities corresponding to time T and the current quaternion~~;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion; and

providing content based on the resulting deviation in the spatial reference frame.

16. (Original) The method of claim 15, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of an electronic device in a spatial reference frame.

17. (Original) The method of claim 15, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

18. (Original) The method of claim 15, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

19. (Original) The method of claim 15, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

20. (Canceled)

21. (Original) The method of claim 15, wherein the content is visual content.

22. (Original) The method of claim 21, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

23. (Original) The method of claim 22, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

24. (Original) The method of claim 15, wherein:

the method further comprises generating, with a magnetometer having magnetometer circuitry, measured magnetism; and

calculating the resulting deviation further comprises:

converting the measured magnetisms corresponding to time T to a measured yaw angle and converting the angular velocities corresponding to time T to a predicted yaw angle;

comparing the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtaining the updated quaternion based on the second comparison result.

25. (Original) The method of claim 24, wherein:

the measured yaw is calculated and obtained based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

26. (Original) The method of claim 24, wherein calculating the resulting deviation further comprises:

obtaining a first updated quaternion based on the current quaternion and the first comparison result; and

obtaining a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

27. (Original) The method of claim 15, wherein calculating the resulting deviation further comprises:

utilizing a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtaining the updated quaternion in response to determining that the compensation is needed.

28. (Original) The method of claim 27, wherein calculating the resulting deviation further comprises utilizing the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range.

29. (New) The electronic device of claim 1, wherein:

the computing processor converts variables (q_0, q_1, q_2 and q_3) of the current quaternion into predicted axial accelerations (Ax′, Ay′, Az′) associated with the pitch and roll angles of the electronic device based on the equations of:

$Ax' = 2(q_1q_3 - q_0q_2)$;

$Ay' = 2(q_2q_3 + q_0q_1)$;

$Az' = q_0^2 - q_1^2 - q_2^2 + q_3^2$; and

the pitch and roll angles of the electronic device are represented by:

pitch = $\arcsin(2(q_0q_2 - q_3q_1))$;

roll = arctan $(2(q_0q_1 + q_2q_3) / (q_0^2 - q_1^2 - q_2^2 + q_3^2))$; and

yaw = arctan $(2(q_0q_3 + q_1q_2) / (q_0^2 + q_1^2 - q_2^2 - q_3^2))$.

30. (New) The method of claim 15, wherein:

the computing processor converts variables (q_0, q_1, q_2 and q_3) of the current quaternion into predicted axial accelerations (Ax′, Ay′, Az′) associated with the pitch and roll angles of the electronic device based on the equations of:

$Ax' = 2(q_1q_3 - q_0q_2)$;

$Ay' = 2(q_2q_3 + q_0q_1)$;

$Az' = q_0^2 - q_1^2 - q_2^2 + q_3^2$; and

wherein the pitch and roll angles of the electronic device are represented by:

pitch = arcsin $(2(q_0q_2 - q_3q_1))$;

roll = arctan $(2(q_0q_1 + q_2q_3) / (q_0^2 - q_1^2 - q_2^2 + q_3^2))$; and

yaw = arctan $(2(q_0q_3 + q_1q_2) / (q_0^2 + q_1^2 - q_2^2 - q_3^2))$.

REMARKS

The Examiner is thanked for the thorough examination of the present application. The Office Action, however, tentatively rejected claims 1-5, 7-19, and 21-28. In response, Applicant respectfully submits the foregoing amendments, in which claims 1 and 15 are amended and new claims 29 and 30 are added. Support for new claim 29 and 30 may be found at various portions of the application as originally filed, thus no new matter is added. Reconsideration of this application, as amended, is respectfully requested.

Claim Rejections - 35 USC § 103

The Office Action indicates that claims 1-5, 7-19, and 21-28 are rejected under 35 U.S.C. 103 as allegedly being unpatentable over Yamashita, et al. (U.S. 8,267,785, hereinafter "Yamashita") in view of Bachmann, et al. (U.S. 7,089,148, hereinafter, "Bachmann"). Applicant respectfully traverses the rejection for at least the reasons described below.

Independent Claim 1 is Allowable

Claim 1, as amended, recites:

> 1. An electronic device subject to movements and rotations in a spatial reference frame, comprising:
> a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and
> a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by ***performing the following in sequence***:
> ***providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T;***
> ***converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current***

> ***quaternion corresponding to time T, <u>without using measured axial accelerations corresponding to time T</u>;***
>
> ***converting variables of the current quaternion into predicted axial accelerations corresponding to time T, <u>which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device</u>;***
>
> comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;
>
> obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;
>
> using the updated quaternion as a next occurrence of the previous quaternion; and
>
> providing the resulting deviation based on the updated quaternion;
>
> wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

(Emphasis Added).

Applicant respectfully asserts that the cited art is legally deficient for rendering claim 1 unpatentable. In particular, the cited art (either individually or in combination) does teach or reasonably suggest at least the features emphasized above in claim 1.

In relying on the cited art in the Final Office Action, the Office references the Terminal Decision of IPR 2019-00143, which involves U.S. 8,441,438 and, in particular, the discussion on pages 70-72 related to limitation 1(m). Applicant respectfully notes that limitation 1(m) recites "an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set". That claim language, however, is not recited in the claims currently under examination. Applicant will now set forth several distinguishing aspects of the claims currently under examination to highlight the inapplicability of the findings of the Terminal Decision as well as the teachings of the cited art.

In this regard, Applicant has amended claim 1 to recite "providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1

and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T" and "converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T". (Emphasis added). Notably, each of "the predicted axial accelerations", "the measured angular velocities" and "the current quaternion" recited in claim 1 are manifest in the same cycle – that is, each corresponds to time T. These relationships (and the corresponding non-use of information available at time T for deriving the features) are not disclosed or suggested in Yamashita and/or Bachmann and the other references (either individually or in combination) are inadequate for remedying these deficiencies.

Additionally, the recitation of the aforementioned features in combination with the express limitation of "performing the following in sequence" is believed to further distinguish over the cited art as noted in the Advisory Action.

With respect to Bachmann, it appears that the computed measurement vector of Fig. 3, box 35a (correlated with "predicted axial accelerations" in the Office Action) is associated with a time cycle that leads both the angular rates at box 33 (correlated with "measured angular velocities" in the Office Action) and the rate quaternion at box 37 (correlated with "current quaternion" in the Office Action). That is, the angular rates and the rate quaternion of Bachmann are both associated with a previous time cycle when compared to the computed measurement vector. Of significance, the computed measurement vector (box 35a) is combined with the rate quaternion (box 37) downstream of box 41 and prior to output 39. Therefore, the process flow of Bachmann prevents any "predicted axial accelerations corresponding to time T" from being based on measured angular velocities corresponding to time T (in fact, they are based

on measured angular velocities corresponding to time T - 1). Based on the above, Applicant respectfully asserts that claim 1 is in condition for allowance.

Independent Claim 15 is Allowable

Claim 15, as amended, recites:

> 15. A method for determining movements and rotations in a spatial reference frame, comprising:
> generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;
> calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by ***performing the following in sequence***:
> ***providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T;***
> ***converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T;***
> ***converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device;***
> comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;
> obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;
> using the updated quaternion as a next occurrence of the previous quaternion; and
> providing the resulting deviation based on the updated quaternion; and
> providing content based on the resulting deviation in the spatial reference frame.

(Emphasis Added).

Applicant respectfully asserts that the cited art is legally deficient for rendering claim 15 unpatentable. In particular, the cited art (either individually or in combination) does teach or reasonably suggest at least the features emphasized above in claim 15 for reasons similar to

those discussed in detail with respect to the rejection of claim 1. Therefore, Applicant respectfully asserts that claim 15 is in condition for allowance.

Dependent Claims are Allowable

Applicant respectfully asserts that the pending dependent claims are allowable for incorporating the features of their respective independent claims. Additionally, these claims recite other features that may serve as independent bases for patentability.

CONCLUSION

Favorable reconsideration and allowance of the present application and all pending claims are hereby courteously requested.

Should the Examiner feel that further discussion of the application is conducive to prosecution and allowance thereof, please do not hesitate to contact the undersigned by phone (678-483-8899).

No fee is believed to be due in connection with this submission other than those, which may have already been provided. If, however, any fee is believed to be due, you are hereby authorized to charge any such fee to deposit account No. 50-5954.

Respectfully submitted,

/M.PaulQualey,Jr./

By: _____

M. Paul Qualey, Jr.
Registration No. 43,024

Customer No. 109673

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

109673 7590 08/18/2022

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 550
Atlanta, GA 30339

EXAMINER	
EARLES, BRYAN E	

ART UNIT	PAPER NUMBER
2625	

NOTIFICATION DATE	DELIVERY MODE
08/18/2022	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):

callie.reynolds@mqrlaw.com
dan.mcclure@mqrlaw.com
uspatents@mqrlaw.com

PTOL-90A (Rev. 04/07)

Office Action Summary	**Application No.** 16/953,771	**Applicant(s)** LIOU et al.	
	Examiner BRYAN EARLES	**Art Unit** 2625	**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 28 July 2022.

☐ 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) 1-5,7-19 and 21-30 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) 1-5,7-19 and 21-30 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 _____ 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 _____.

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

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

The Office acknowledges the Request for Continued Examination (RCE) dated 28 July 2022, in which:

Claims **1-5, 7-19 and 21-30** are currently pending.

Claims **1 and 15** are amended.

Claims **29 and 30** are new.

Claim Rejections - 35 USC § 103

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.

Claims 1-5, 7-19 and 21-30 are rejected under 35 U.S.C. 103 as being unpatentable over Yamashita et al. (US 8,267,785, hereinafter "Yamashita") in view of Bachmann et al. (US 7,089,148, hereinafter "Bachmann") and Zhao et al. (US 2011/0307213, hereinafter "Zhao").

With respect to **Claim 1** (Currently Amended), Yamashita teaches an electronic device subject to movements and rotations in a spatial reference frame (Yamashita: Fig. 1-3), comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations (Yamashita: Fig. 7, gyrosensor unit 7 includes gyrosensors 55 and 56 for producing tri-axial angular velocity data).

Yamashita fails to expressly disclose:

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1;

converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

However, Bachmann discloses:

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame (Bachmann: Fig. 3, the angular rates (p, q, r) at box 33 correspond to measured movements and rotations in a sensor reference frame) by performing the following in sequence:

comparing (Paragraph [0004], of Applicant's Specification, "The term of "comparison" of the present invention may generally refer to the calculating and obtaining of the actual deviation angles of the 3D pointing device ...") the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result (Bachmann: Fig. 3, the comparison occurs at the junction between boxes 34 and 35, such that the filter chooses a correction factor, that when added to q.dot., will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values);

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, and using the updated quaternion as a next occurrence of the previous quaternion (Bachmann: Fig. 3, the updated quaternion is a new value of the orientation output quaternion at 39); and

providing the resulting deviation based on the updated quaternion (Bachmann: Fig. 3, the updated quaternion reflects the correction factor using predicted measurements based on the previous orientation output quaternion);

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame (Bachmann: Fig. 4, processing unit

translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

Therefore, it would be obvious to one of ordinary skill in the art at the time the invention was made to modify the device, as taught by Yamashita, to incorporate additional types of detectors into the motion sensing module, as taught by Bachmann, in order overcome the shortcomings of individual detector types by capitalizing on the advantages of each (Bachmann: Col. 4, lines 15-30, Col. 13, lines 1-10).

Yamashita as modified by Bachmann fail to expressly disclose:

without using measured axial accelerations corresponding to time T,

which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device,

which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device.

However, Zhao discloses:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using measured angular velocities corresponding to time T (Zhao: Paras. [0056], [0063]);

converting the measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T (Zhao: Paras. [0056] – [0063]);

converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device (Zhao: Para. [0063]; claim 21).

Therefore, it would be obvious to one of ordinary skill in the art at the time the invention was made to modify the electronic device, as taught by Yamashita and Bachmann, to incorporate automatic gain adjustment of the filter with respect to the magnetic field measurements, as taught by Zhao, in order to mitigate the effect of magnetic field disturbance, and thus, achieve more accurate state estimation (Zhao: Para. [0083] – [[0084]).

With respect to **Claim 29** (New), the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 1, wherein:

the computing processor converts variables (qo, qi, q2 and q3) of the current quaternion into predicted axial accelerations (Ax', Ay', Az') associated with the pitch and roll angles of the electronic device based on the equations of:

$Ax' = 2(q_1q_3 - q_0q_2)$;

$Ay' = 2(q_2q_3 + q_0q_1)$;

$Az' = q_0^2 - q_1^2 - q_2^2 + q_3^2$; and

wherein the pitch and roll angles of the electronic device are represented by:

$\text{pitch} = \arcsin(2(q_0q_2 - q_3q_1))$;

$\text{roll} = \arctan(2(q_0q_1 + q_2q_3) / (q_0^2 - q_1^2 - q_2^2 + q_3^2))$; and

$\text{yaw} = \arctan(2(q_0q_3 + q_1q_2) / (q_0^2 + q_1^2 - q_2^2 - q_3^2))$.

(Zhao: Eqn. (7) and (8) discloses:

[0058] The carrier body frame-to-local navigation frame cosine rotation matrix is directly formed using the attitude quaternion as:

$$C_b^n = \begin{bmatrix} q_0^2 + q_1^2 - q_2^2 - q_3^2 & 2(q_1q_2 - q_0q_3) & 2(q_1q_3 + q_0q_2) \\ 2(q_1q_2 + q_0q_3) & q_0^2 - q_1^2 + q_2^2 - q_3^2 & 2(q_2q_3 - q_0q_1) \\ 2(q_1q_3 - q_0q_2) & 2(q_2q_3 + q_0q_1) & q_0^2 - q_1^2 - q_2^2 + q_3^2 \end{bmatrix} \quad (7)$$

[0059] Dynamic roll, dynamic pitch, and dynamic yaw angles can be abstracted from the cosine rotation matrix, C_b^n as follows:

$$\phi = \text{roll} = \arctan\left(\frac{C_b^n(3,2)}{C_b^n(3,3)}\right) \quad (8)$$

$$\theta = \text{pitch} = -\arcsin C_b^n(3,1)$$

$$\psi = \text{yaw} = \arctan\left(\frac{C_b^n(2,1)}{C_b^n(1,1)}\right)$$

).

With respect to **Claim 2**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 1, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer (Yamashita: Fig. 7, gyrosensor unit 7 and acceleration sensor 37);

the rotation sensor has sensor circuitry configured to generate the measured angular velocities (Yamashita: Fig. 7, gyrosensor unit 7 includes gyrosensors 55 and 56 for producing tri-axial angular velocity data);

the accelerometer has circuitry configured to generate the measured axial accelerations (Yamashita: Fig. 7; Col. 12, line 47 – Col. 13, line 10, output from the acceleration sensor 37 represented as a three-dimensional acceleration vector (ax,ay,az));

and both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame (Yamashita: Fig. 7; Col. 12, line 47 – Col. 13, line 10, output from the acceleration sensor 37 represented as a three-dimensional vector (ax,ay,az) in a XYZ coordinate system).

With respect to **Claim 3**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding

to time T (Bachmann: Fig. 3, the angular rates at box 33 are converted at box 37 to a rate quaternion).

With respect to **Claim 4** the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 1, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T (Bachmann: Fig. 3, an estimated orientation quaternion 39 is correlated with the measurement vector 34 and the angular rate information 37; Col. 16, line 40 – Col. 17, line 5, each iteration computes an updated estimated quaternion representative of a new estimate of sensor orientation).

With respect to **Claim 5**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 1, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T (Bachmann: Fig. 3, the comparison occurs at the junction between boxes 34 and 35, such that the filter chooses a correction factor, that when added to q.dot., will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values).

With respect to **Claim 7**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 1, wherein the content is visual content (Bachmann: Fig. 4, Col. 13, lines 20-30).

With respect to **Claim 8**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 7, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame (Bachmann: Fig. 4, processing unit translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

With respect to **Claim 9**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 8, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern (Bachmann: Fig. 4, processing unit translates movements of the person 402 from the sensor reference frame into the display reference frame 404).

With respect to **Claim 10**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 1, wherein:

the motion sensor module further comprises a magnetometer having magnetometer circuitry configured to generate measured magnetisms (Bachmann: Fig. 3, magnetometers 38 generate measured magnetisms b1, b2, b3); and

in calculating the resulting deviation, the computing processor is further configured to:

convert the measured magnetisms corresponding to time T to a measured yaw angle (Bachmann: Fig. 3, box 32 outputs measured magnetisms b1, b2, b3 corresponding to yaw pitch and roll angles) and convert the angular velocities corresponding to time T to a predicted yaw angle (Bachmann: Fig. 3, box 33 outputs signal (p, q, r) comprising angular velocities Ωx, Ωy, Ωz. used to calculate each output $\hat{q}$ and are therefore a part of each orientation output quaternion q);

compare the predicted yaw angle with the measured yaw angle to obtain a second comparison result (Bachmann: Fig. 3, measured magnetisms are compared with respective predicted magnetisms in the computed measurement vector 35a to obtain a six-valued error vector 36 that corresponds to measure of how actual accelerometer and magnetometer measurements differ from the what the filter predicts those measurements should be, based on the angular rate sensor output (Bachmann: Fig. 3, the filter selects a correction factor output at box 41 that when added to the output at box 37 will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values); and

obtain the updated quaternion based on the second comparison result (Bachmann: Fig. 3, the filter selects a correction factor output at box 41 that when added to the output at box 37 will minimize the difference between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values).

With respect to **Claim 11**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 10, wherein:

the measured yaw is based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion (Bachmann: Fig. 3, includes intermediate sensor orientations represented in the form of quaternions (e.g., old and new q.sub.circumflex); Col. 7, lines 4-31; transforming estimated body rates to updated Euler Rates or Quaternion Rates).

With respect to **Claim 12**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 10, wherein, in calculating the resulting deviation, the computing processor is further configured to:

obtain a first updated quaternion based on the current quaternion and the first comparison result (Bachmann: Fig. 3, an estimated orientation quaternion 39 is correlated with the measurement vector 34 and the angular rate information 37; Col. 16, line 40 – Col. 17, line 5, each iteration computes an updated estimated quaternion representative of a new estimate of sensor orientation); and

obtain a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion (Bachmann: Col. 9, lines 22-32; Fig. 3, a second updated state is interpreted as a subsequent iteration using the previously updated state; Equation 16).

With respect to **Claim 13**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtain the updated quaternion in response to determining that the compensation is needed (Bachmann: Fig. 3; performing compensation if the error vector yields a non-zero result, then no deviation exist in the subtracting operation between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values when no compensation is performed).

With respect to **Claim 14**, the combination of Yamashita as modified by Bachmann and Zhao teaches the electronic device of claim 13, wherein, in calculating the resulting deviation, the computing processor is further configured to utilize the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range (Bachmann: Fig. 3; performing the compensation only if the error vector yields a non-zero result, otherwise if no deviation exist in the subtracting operation between the actual measurements (h1 h2 h3 b1 b2 b3) and the predicted measurements for those same values, then no compensation is performed).

Method claims (15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28 & 30) are drawn to the method of using the corresponding apparatus claimed in claims (1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14 & 29). Therefore, method claims (15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28 & 30) correspond to apparatus claims (1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14 & 29) and are rejected for the same reasons of obviousness as used above.

Response to Arguments/Amendments/Remarks

Applicant's arguments with respect to claims 1-5, 7-19 and 21-30 have been considered but are moot because the arguments do not apply to the combination of references used in the current rejection.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to BRYAN EARLES whose telephone number is (571)272-4628. The examiner can normally be reached on Monday - Thursday at 7:30am - 5:00pm.

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, William Boddie can be reached on 571-272-0666. 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.

/BRYAN EARLES/
Primary Examiner, Art Unit 2625

/WILLIAM BODDIE/
Supervisory Patent Examiner, Art Unit 2625

Notice of References Cited	Application/Control No. 16/953,771	Applicant(s)/Patent Under Reexamination LIOU et al.	
	Examiner BRYAN EARLES	Art Unit 2625	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-20110307213-A1	12-2011	Zhao; Yang	G01C17/30	73/514.31
	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.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
16/953,771	01/06/2023 01:21:39 PM ET	250303-1022

Title of Invention

ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1038	FILED BY	Brooke French
PATENT CENTER #	61399201	AUTHORIZED BY	Michael Qualey
CUSTOMER #	109673	FILING DATE	11/20/2020
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Shun-Nan LIOU

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 1007	E202316D22270025	Brooke French

PRE-AUTHORIZED ACCOUNT	PRE-AUTHORIZED CATEGORY
505954	37 CFR 1.16 (National application filing, search, and examination fees); 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)

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
2252	EXTENSION FOR RESPONSE WITHIN SECOND MONTH -	256.00	1	256.00
			TOTAL AMOUNT:	$256.00

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 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.

PTO/AIA/22 (12-22)
Approved for use through 05/31/2024. OMB 0651-0031
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.

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)	Docket Number (Optional) 250303-1022
Application Number 16/953,771	Filed November 20, 2020
For ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF	
Art Unit 2625	Examiner Earles, Bryan E.

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))	$220	$88	$44	$
☑	Two months (37 CFR 1.17(a)(2))	$640	$256	$128	$ 256.00
☐	Three months (37 CFR 1.17(a)(3))	$1,480	$592	$296	$
☐	Four months (37 CFR 1.17(a)(4))	$2,320	$928	$464	$
☐	Five months (37 CFR 1.17(a)(5))	$3,160	$1,264	$632	$

☐ 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 50-5954.

☑ Payment made via USPTO's patent electronic filing system (Patent Center or EFS-Web).

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 43,024.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/M.PaulQualey,Jr./	1/6/2023
Signature	Date
M. Paul Qualey, Jr.	678-483-8899
Typed or printed name	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 _____ forms are submitted.

A Federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with an information collection subject to the requirements of the Paperwork Reduction Act of 1995, unless the information collection has a currently valid OMB Control Number. The OMB Control Number for this information collection is 0651-0031. Public burden for this form is estimated to average 6 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection. Send comments regarding this burden estimate or any other aspect of this information collection, including suggestions for reducing this burden to the Chief Administrative Officer, United States Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450 or email InformationCollection@uspto.gov. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS**. If filing this completed form by mail, 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. The United States Patent and Trademark Office (USPTO) collects the information in this record under authority of 35 U.S.C. 2. The USPTO's system of records is used to manage all applicant and owner information including name, citizenship, residence, post office address, and other information with respect to inventors and their legal representatives pertaining to the applicant's/owner's activities in connection with the invention for which a patent is sought or has been granted. The applicable Privacy Act System of Records Notice for the information collected in this form is COMMERCE/PAT-TM-7 Patent Application Files, available in the Federal Register at 78 FR 19243 (March 29, 2013). https://www.govinfo.gov/content/pkg/FR-2013-03-29/pdf/2013-07341.pdf

Routine uses of the information in this record may include disclosure to: 1) law enforcement, in the event that the system of records indicates a violation or potential violation of law; 2) a Federal, state, local, or international agency, in response to its request; 3) a contractor of the USPTO having need for the information in order to perform a contract; 4) the Department of Justice for determination of whether the Freedom of Information Act (FOIA) requires disclosure of the record; 5) a Member of Congress submitting a request involving an individual to whom the record pertains, when the individual has requested the Member's assistance with respect to the subject matter of the record; 6) a court, magistrate, or administrative tribunal, in the course of presenting evidence, including disclosures to opposing counsel in the course of settlement negotiations; 7) the Administrator, General Services Administration (GSA), or their designee, during an inspection of records conducted by GSA under authority of 44 U.S.C. 2904 and 2906, in accordance with the GSA regulations and any other relevant (i.e., GSA or Commerce) directive, where such disclosure shall not be used to make determinations about individuals; 8) 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)); 9) the Office of Personnel Management (OPM) for personnel research purposes; and 9) the Office of Management and Budget (OMB) for legislative coordination and clearance.

If you do not furnish the information requested on this form, the USPTO may not be able to process and/or examine your submission, which may result in termination of proceedings, abandonment of the application, and/or expiration of the patent.

Additional Uses

Additional USPTO uses of the information in this record may include disclosure to: 1) the International Bureau of the World Intellectual Property Organization, if the record is related to an international application filed under the Patent Cooperation Treaty; 2) the public i) after publication of the application pursuant to 35 U.S.C. 122(b), ii) after issuance of a patent pursuant to 35 U.S.C. 151, iii) 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, or iv) without publication of the application or patent under the specific circumstances provided for by 37 CFR 1.14(a)(1)(v)-(vii); and/or 3) the National Archives and Records Administration, for inspection of records.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
16/953,771	**01/06/2023 01:21:39 PM ET**	**250303-1022**

Title of Invention

ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1038	FILED BY	Brooke French
PATENT CENTER #	61399201	FILING DATE	11/20/2020
CUSTOMER #	109673	FIRST NAMED INVENTOR	Shun-Nan LIOU
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Michael Qualey

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
01043004.PDF	2	Extension of Time	328 KB
01043235.PDF	16	Amendment/Request for Reconsideration-After Non-Final Rejection	144 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
01043004.PDF	A8F65FC8AF27EB7A4D9A6F0ED7F258F8C9C93A7D4FF67733 DB2FB2D0061A422DE00FF8535E5AAA23790B0444EA277E87C

	6073D1ECD53A46F2EA647316801331F
01043235.PDF	E418E5F20F38E5B53531D3C418B407A4A256EC333D77EB84A ABF9894882BFAA1E88A6C9041656106BC99F52964FE3E218B9 EFE02339C61EC854FE9221D3C90F2

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 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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:

Shun-Nan LIOU, et al.

Serial No.: 16/953,771

Filed: November 20, 2020

For: Electronic Device for Use in Motion Detection and Method for Obtaining Resultant Deviation Thereof

Confirmation No.: 1038

Group Art Unit: 2625

Examiner: Earles, Bryan E.

Docket No.: 250303-1022

AMENDMENT AND RESPONSE TO NON-FINAL OFFICE ACTION

Mail Stop: Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Director:

The outstanding Non-Final Office Action mailed 18 August 2022 has been carefully considered. In response thereto, please enter the following remarks. Reconsideration and allowance of the application and presently pending claims are respectfully requested.

AMENDMENTS

In the Claims

1. (Previously Presented) An electronic device subject to movements and rotations in a spatial reference frame, comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by performing the following in sequence:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T;

converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T;

converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

2. (Original) The electronic device of claim 1, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame.

3. (Original) The electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

4. (Original) The electronic device of claim 1, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

5. (Original) The electronic device of claim 1, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

6. (Canceled)

7. (Original) The electronic device of claim 1, wherein the content is visual content.

8. (Original) The electronic device of claim 7, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

9. (Original) The electronic device of claim 8, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

10. (Original) The electronic device of claim 1, wherein:

the motion sensor module further comprises a magnetometer having magnetometer circuitry configured to generate measured magnetisms; and

in calculating the resulting deviation, the computing processor is further configured to:

convert the measured magnetisms corresponding to time T to a measured yaw angle and convert the angular velocities corresponding to time T to a predicted yaw angle;

compare the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtain the updated quaternion based on the second comparison result.

11. (Original) The electronic device of claim 10, wherein:

the measured yaw is based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

12. (Original) The electronic device of claim 10, wherein, in calculating the resulting deviation, the computing processor is further configured to:

obtain a first updated quaternion based on the current quaternion and the first comparison result; and

obtain a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

13. (Original) The electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtain the updated quaternion in response to determining that the compensation is needed.

14. (Original) The electronic device of claim 13, wherein, in calculating the resulting deviation, the computing processor is further configured to utilize the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range.

15. (Previously Presented) A method for determining movements and rotations in a spatial reference frame, comprising:

generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;

calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by performing the following in sequence:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T;

converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T;

converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion; and

providing content based on the resulting deviation in the spatial reference frame.

16. (Original) The method of claim 15, wherein:

the motion sensor module further comprises a rotation sensor and an accelerometer;

the rotation sensor has sensor circuitry configured to generate the measured angular velocities;

the accelerometer has circuitry configured to generate the measured axial accelerations; and

both the rotation sensor and the accelerometer are associated with the movements and the rotations of an electronic device in a spatial reference frame.

17. (Original) The method of claim 15, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.

18. (Original) The method of claim 15, wherein the predicted axial accelerations are based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T.

19. (Original) The method of claim 15, wherein the first comparison result is based on the measured axial accelerations corresponding to time T-1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T.

20. (Canceled)

21. (Original) The method of claim 15, wherein the content is visual content.

22. (Original) The method of claim 21, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.

23. (Original) The method of claim 22, further comprising a display device associated with the display reference frame and configured to display the real-time movement pattern.

24. (Original) The method of claim 15, wherein:

the method further comprises generating, with a magnetometer having magnetometer circuitry, measured magnetism; and

calculating the resulting deviation further comprises:

converting the measured magnetisms corresponding to time T to a measured yaw angle and converting the angular velocities corresponding to time T to a predicted yaw angle;

comparing the predicted yaw angle with the measured yaw angle to obtain a second comparison result; and

obtaining the updated quaternion based on the second comparison result.

25. (Original) The method of claim 24, wherein:

the measured yaw is calculated and obtained based on the measured magnetisms, a temporary pitch value, and a temporary roll value; and

the temporary pitch value and the temporary roll value are calculated and converted from the updated quaternion.

26. (Original) The method of claim 24, wherein calculating the resulting deviation further comprises:

obtaining a first updated quaternion based on the current quaternion and the first comparison result; and

obtaining a second updated quaternion based on the first updated quaternion and the second comparison result, wherein the resultant angles are based on the second updated quaternion.

27. (Original) The method of claim 15, wherein calculating the resulting deviation further comprises:

utilizing a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

obtaining the updated quaternion in response to determining that the compensation is needed.

28. (Original) The method of claim 27, wherein calculating the resulting deviation further comprises utilizing the first data association model to determine whether compensation is needed to obtain the updated quaternion based on whether the first comparison result is a first predetermined value or within a first predetermined range.

29. (Previously Presented) The electronic device of claim 1, wherein:

the computing processor converts variables (q_0, q_1, q_2 and q_3) of the current quaternion into predicted axial accelerations (Ax′, Ay′, Az′) associated with the pitch and roll angles of the electronic device based on the equations of:

$Ax' = 2(q_1q_3 - q_0q_2)$;

$Ay' = 2(q_2q_3 + q_0q_1)$;

$Az' = q_0^2 - q_1^2 - q_2^2 + q_3^2$; and

the pitch and roll angles of the electronic device are represented by:

$\text{pitch} = \arcsin(2(q_0q_2 - q_3q_1))$;

$\text{roll} = \arctan(2(q_0q_1 + q_2q_3) / (q_0^2 - q_1^2 - q_2^2 + q_3^2))$; and

$\text{yaw} = \arctan(2(q_0q_3 + q_1q_2) / (q_0^2 + q_1^2 - q_2^2 - q_3^2))$.

30. (Previously Presented) The method of claim 15, wherein:

the computing processor converts variables (q_0, q_1, q_2 and q_3) of the current quaternion into predicted axial accelerations (Ax′, Ay′, Az′) associated with the pitch and roll angles of the electronic device based on the equations of:

$Ax' = 2(q_1q_3 - q_0q_2)$;

$Ay' = 2(q_2q_3 + q_0q_1)$;

$Az' = q_0^2 - q_1^2 - q_2^2 + q_3^2$; and

wherein the pitch and roll angles of the electronic device are represented by:

$\text{pitch} = \arcsin(2(q_0q_2 - q_3q_1))$;

$\text{roll} = \arctan(2(q_0q_1 + q_2q_3) / (q_0^2 - q_1^2 - q_2^2 + q_3^2))$; and

$\text{yaw} = \arctan(2(q_0q_3 + q_1q_2) / (q_0^2 + q_1^2 - q_2^2 - q_3^2))$.

REMARKS

The Examiner is thanked for the thorough examination of the present application. The Office Action, however, tentatively rejected claims 1-5, 7-19, and 21-30. In response, Applicant respectfully submits the following remarks. Reconsideration of this application is respectfully requested.

Claim Rejections - 35 USC § 103

The Office Action indicates that claims 1-5, 7-19, and 21-30 are rejected under 35 U.S.C. 103 as allegedly being unpatentable over Yamashita, et al. (U.S. 8,267,785, hereinafter "Yamashita") in view of Bachmann, et al. (U.S. 7,089,148, hereinafter, "Bachmann") and Zhao, et al. (U.S. 2011/0307213, hereinafter "Zhao"). Applicant respectfully traverses the rejection for at least the reasons described below.

In this regard, Applicant has thoroughly reviewed the disclosure of Zhao and its parent applications 11/825993, 60/819735, and 60/906100. Applicant respectfully asserts that none of the parent applications supports the features relied upon by the Office in formulating the pending rejection. Because of this, the critical date of the disclosure of Zhao should be 28 July 2011 – the filing date of the Zhao application (13/193,139, which published as U.S. 2011/0307213).

Additionally, the features recited in the presently pending claims are fully supported by at least the disclosure of US 9,760,186 (filed on 28 March 2011), which predates the critical date of Zhao. Therefore, Applicant respectfully asserts that Zhao is not prior art with respect to the pending claims and should be removed as a prior art reference.

Independent Claim 1 is Allowable

Claim 1 recites:

> 1. An electronic device subject to movements and rotations in a spatial reference frame, comprising:
>
> a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and
>
> a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by ***performing the following in sequence***:
>
> ***providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T;***
>
> ***converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T***;
>
> ***converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device***;
>
> comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;
>
> obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;
>
> using the updated quaternion as a next occurrence of the previous quaternion; and
>
> providing the resulting deviation based on the updated quaternion;
>
> wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.

(Emphasis Added).

Applicant respectfully asserts that the cited art is legally deficient for rendering claim 1 unpatentable. In particular, the cited art (either individually or in combination) does teach or reasonably suggest at least the features emphasized above in claim 1 as the Office admits that

Yamashita in view of Bachmann fail to expressly disclose the features emphasized above in claim 1, and Zhao is not prior art capable of remedying the deficiency.

Independent Claim 15 is Allowable

Claim 15 recites:

> 15. A method for determining movements and rotations in a spatial reference frame, comprising:
> generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;
> calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by ***performing the following in sequence***:
> ***providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T***;
> ***converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T***;
> ***converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device***;
> comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;
> obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;
> using the updated quaternion as a next occurrence of the previous quaternion; and
> providing the resulting deviation based on the updated quaternion; and
> providing content based on the resulting deviation in the spatial reference frame.

(Emphasis Added).

Applicant respectfully asserts that the cited art is legally deficient for rendering claim 15 unpatentable. In particular, the cited art (either individually or in combination) does teach or reasonably suggest at least the features emphasized above in claim 15 for reasons similar to

those discussed in detail with respect to the rejection of claim 1. Therefore, Applicant respectfully asserts that claim 15 is in condition for allowance.

Dependent Claims are Allowable

Applicant respectfully asserts that the pending dependent claims are allowable for incorporating the features of their respective independent claims. Additionally, these claims recite other features that may serve as independent bases for patentability.

CONCLUSION

Favorable reconsideration and allowance of the present application and all pending claims are hereby courteously requested.

Should the Examiner feel that further discussion of the application is conducive to prosecution and allowance thereof, please do not hesitate to contact the undersigned by phone (678-483-8899).

No fee is believed to be due in connection with this submission other than those, which may have already been provided. If, however, any fee is believed to be due, you are hereby authorized to charge any such fee to deposit account No. 50-5954.

Respectfully submitted,

/M.PaulQualey,Jr./

By: _____

M. Paul Qualey, Jr.

Registration No. 43,024

Customer No. 109673

Notice of Allowability	Application No. 16/953,771	Applicant(s) LIOU et al.	
	Examiner BRYAN EARLES	Art Unit 2625	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 06 January 2023.
   ☐ 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 1-5,7-19 and 21-30 . 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 _____.

/BRYAN EARLES/
Primary Examiner, Art Unit 2625

Notice of Pre-AIA or AIA Status

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

Allowable Subject Matter

The following is an examiner's statement of reasons for allowance:

Claims (1-5,7-19 and 21-30) are allowed as the prior art does not teach or suggest the applicant's invention.

The claims and Applicant's remarks (dated 06 January 2023) distinguishes the Applicant's invention over the cited prior art. The various claimed limitations mentioned in the claims are not taught or suggested by the prior art taken either singly or in combination, with emphasis that it is each claim, taken as a whole, including the interrelationships and interconnections between various claimed elements make them allowable over the prior art of record. In particular, none of the cited prior art teaches or reasonably suggests:

"An electronic device subject to movements and rotations in a spatial reference frame, comprising:

a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and

a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by performing the following in sequence:

providing a previous quaternion corresponding to time T-1 based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1, without using the measured angular velocities corresponding to time T;

converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T;

converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device;

comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;

obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;

using the updated quaternion as a next occurrence of the previous quaternion; and

providing the resulting deviation based on the updated quaternion;

wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Bryan Earles whose telephone number is (571)272-4628. The examiner can normally be reached on Monday-Friday at 8am-5pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, William Boddie can be reached on (571)272-0666. 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.

/BRYAN EARLES/
Primary Examiner, Art Unit 2625

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

109673 7590 02/27/2023

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 530
Atlanta, GA 30339

EXAMINER
EARLES, BRYAN E

ART UNIT	PAPER NUMBER
2625	

DATE MAILED: 02/27/2023

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

TITLE OF INVENTION: ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	05/30/2023

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 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted 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. 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.

PTOL-85 (Rev. 02/11)

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)

109673 7590 02/27/2023

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 530
Atlanta, GA 30339

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.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

TITLE OF INVENTION: ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	05/30/2023

EXAMINER	ART UNIT	CLASS-SUBCLASS
EARLES, BRYAN E	2625	345-156000

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/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 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. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

109673 7590 02/27/2023

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 530
Atlanta, GA 30339

EXAMINER	
EARLES, BRYAN E	

ART UNIT	PAPER NUMBER
2625	

DATE MAILED: 02/27/2023

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.

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.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
16/953,771	05/24/2023 09:13:20 AM ET	250303-1022

Title of Invention

ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1038	FILED BY	Brooke French
PATENT CENTER #	62144677	AUTHORIZED BY	Michael Qualey
CUSTOMER #	109673	FILING DATE	11/20/2020
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Shun-Nan LIOU

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 1007	E20235N014057331	Brooke French

PRE-AUTHORIZED ACCOUNT	PRE-AUTHORIZED CATEGORY
505954	37 CFR 1.16 (National application filing, search, and examination fees); 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)

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
2501	UTILITY ISSUE FEE	480.00	1	480.00
			TOTAL AMOUNT:	$480.00

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 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.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
16/953,771	**05/24/2023 09:13:20 AM ET**	**250303-1022**

Title of Invention

ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1038	FILED BY	Brooke French
PATENT CENTER #	62144677	FILING DATE	11/20/2020
CUSTOMER #	109673	FIRST NAMED INVENTOR	Shun-Nan LIOU
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Michael Qualey

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
01082205.PDF	1	Issue Fee Payment (PTO-85B)	1239 KB

Warning: The attached file contains comments or annotations. Comments are not recommended and may cause processing problems with the document.

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
01082205.PDF	69AAEEF75572AB6EFB395890F48D7C5DD55EF036E23545F4B8E61CE2A441DC3532F8D3F9FB81E29D66AA1DA851890343AE6805595B72156812A0B5210B437AC2

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 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.

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)

109673 7590 02/27/2023

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 530
Atlanta, GA 30339

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.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

TITLE OF INVENTION: ELECTRONIC DEVICE FOR USE IN MOTION DETECTION AND METHOD FOR OBTAINING RESULTANT DEVIATION THEREOF

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0.00	$0.00	$480	05/30/2023

EXAMINER	ART UNIT	CLASS-SUBCLASS
EARLES, BRYAN E	2625	345-156000

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/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 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 McClure, Qualey &
2 Rodack, LLP
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: CM HK LIMITED

(B) RESIDENCE: (CITY and STATE OR COUNTRY): FORTRESS HILL, HONG KONG

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual XX Corporation or other private group entity ❑ Government

4a. Fees submitted: XX Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

XX Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

XX The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 50-5954

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 /M.PaulQualey,Jr./ Date 5/23/2023

Typed or printed name M. Paul Qualey, Jr. Registration No. 43,024

PTOL-85 Part B (08-18) Approved for use through 01/31/2020 OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	07/11/2023	11698687	250303-1022	1038

109673 7590 06/21/2023

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 530
Atlanta, GA 30339

ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at https://patentcenter.uspto.gov/. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

The USPTO is implementing electronic patent issuance with a transition period, during which period the USPTO will mail a ceremonial paper copy of the electronic patent grant to the correspondence address of record. Additional copies of the patent (i.e., certified and presentation copies) may be ordered for a fee from the USPTO's Certified Copy Center at https://certifiedcopycenter.uspto.gov/index.html. The Certified Copy Center may be reached at (800)972-6382.

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 0 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 Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PAIR WEB site http://pair.uspto.gov for additional inventors):

Shun-Nan LIOU, Taipei, TAIWAN;
Zhou YE, Taipei, TAIWAN;
Chin-Lung LI, Taipei, TAIWAN;

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

CM HK LIMITED, Fortress Hill, HONG KONG;

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.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/953,771	11/20/2020	Shun-Nan LIOU	250303-1022	1038

109673 7590 07/11/2023

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Suite 530
Atlanta, GA 30339

EXAMINER	
EARLES, BRYAN E	

ART UNIT	PAPER NUMBER
2625	

NOTIFICATION DATE	DELIVERY MODE
07/11/2023	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):

dan.mcclure@mqrlaw.com
terri.logan@mqrlaw.com
uspatents@mqrlaw.com

PTOL-90A (Rev. 04/07)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.
16/953,771	11-Jul-2023	11698687

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE
Atlanta, GA 30339

EGRANT NOTIFICATION

Your electronic patent grant (eGrant) is now available, which can be accessed via Patent Center at https://patentcenter.uspto.gov

The electronic patent grant is the official patent grant under 35 U.S.C. 153. For more information, please visit https://www.uspto.gov/electronicgrants

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 16/953,771	Filing Date 11/20/2020	☐ 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 $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ 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	03/02/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 26	Minus	** 28	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $240 =	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".	/RAMONA D WILSON/
*** 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.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/953,771

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	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	28 minus 20 =	* 8	x 50 =	400	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*	x 240 =	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	1230		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	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
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.

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 16/953,771	Filing Date 11/20/2020	☐ 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 $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ 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	07/28/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 28	Minus	** 28	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $240 =	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".	/ALLYSON PURNELL/
*** 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.

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 16/953,771	Filing Date 11/20/2020	☐ 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 $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ 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	04/14/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 26	Minus	** 28	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $240 =	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".	/JASON B EADDY/
*** 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.

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 16/953,771	Filing Date 11/20/2020	☐ 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 $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ 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

AMENDMENT	01/06/2023	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 28	Minus	** 28	= 0		x $40 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $192 =	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

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) 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".	/MARQUITA D JONES/
*** 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.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/953,771	LIOU et al.
	Examiner	Art Unit
	BRYAN EARLES	2625

CPC - Searched*		
Symbol	Date	Examiner
G06F3/0346, G01C21/165, G06F3/0383	12/04/2021	BE

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
Inventor Search	12/04/2021	BE
G06F3/0346, G01C21/165, G06F3/0383	12/04/2021	BE
IP.com Search	12/04/2021	BE
PE2E SEARCH	12/04/2021	BE
Updated Search	03/17/2022	BE

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

/BRYAN EARLES/ Primary Examiner, Art Unit 2625	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/953,771	LIOU et al.
	Examiner	Art Unit
	BRYAN EARLES	2625

CPC - Searched*		
Symbol	Date	Examiner
G06F3/0346, G01C21/165, G06F3/0383	12/04/2021	BE

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
Inventor Search	12/04/2021	BE
G06F3/0346, G01C21/165, G06F3/0383	12/04/2021	BE
IP.com Search	12/04/2021	BE
PE2E SEARCH	12/04/2021	BE

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

/BRYAN EARLES/ Primary Examiner, Art Unit 2625	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/953,771	LIOU et al.
	Examiner	Art Unit
	BRYAN EARLES	2625

CPC - Searched*		
Symbol	Date	Examiner
G06F3/0346, G01C21/165, G06F3/0383	12/04/2021	BE

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
Inventor Search	12/04/2021	BE
G06F3/0346, G01C21/165, G06F3/0383	12/04/2021	BE
IP.com Search	12/04/2021	BE
PE2E SEARCH	12/04/2021	BE
Updated Search	03/17/2022	BE
Updated Search	08/10/2022	BE

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

/BRYAN EARLES/ Primary Examiner, Art Unit 2625	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/953,771	LIOU et al.
	Examiner	Art Unit
	BRYAN EARLES	2625

CPC - Searched*		
Symbol	Date	Examiner
G06F3/0346, G01C21/165, G06F3/0383	12/04/2021	BE

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
Inventor Search	12/04/2021	BE
G06F3/0346, G01C21/165, G06F3/0383	12/04/2021	BE
IP.com Search	12/04/2021	BE
PE2E SEARCH	12/04/2021	BE
Updated Search	03/17/2022	BE
Updated Search	08/10/2022	BE
Updated Search	02/21/2023	BE

/BRYAN EARLES/ Primary Examiner, Art Unit 2625	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/953,771	LIOU et al.
	Examiner	Art Unit
	BRYAN EARLES	2625

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
G06F	3/0346, 3/0383	02/21/2023	BE
G01C	21/165	02/21/2023	BE

/BRYAN EARLES/ Primary Examiner, Art Unit 2625	

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/953,771	LIOU et al.
	Examiner	**Art Unit**
	BRYAN EARLES	2625

CPC							
Symbol						**Type**	**Version**
G06F	/	3	/	0346		F	2013-01-01
G06F	/	3	/	0383		I	2013-01-01
G01C	/	21	/	1654		I	2020-08-01

CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	28	
/BRYAN EARLES/ Primary Examiner, Art Unit 2625	21 February 2023	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	12

U.S. Patent and Trademark Office — Part of Paper No.: 20230221

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/953,771	LIOU et al.
	Examiner	**Art Unit**
	BRYAN EARLES	2625

INTERNATIONAL CLASSIFICATION					
CLAIMED					
G06F	/	3	/	0346	
G06F	/	3	/	038	
G01C	/	21	/	16	

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	28	
/BRYAN EARLES/ Primary Examiner, Art Unit 2625	21 February 2023	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	12

U.S. Patent and Trademark Office — Part of Paper No.: 20230221

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/953,771	LIOU et al.
	Examiner	**Art Unit**
	BRYAN EARLES	2625

☐ 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
1	1	10	11	19	21	28	30								
2	2	11	12	20	22										
3	3	12	13	21	23										
4	4	13	14	22	24										
5	5	14	15	23	25										
6	7	15	16	24	26										
7	8	16	17	25	27										
8	9	17	18	26	28										
9	10	18	19	27	29										

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	28	
/BRYAN EARLES/ Primary Examiner, Art Unit 2625	21 February 2023	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	12

U.S. Patent and Trademark Office — Part of Paper No.: 20230221