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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
62/543,587	08/10/2017		130	409000A		

145234
RealD Spark, LLC
100 North Crescent Drive
Suite 200
Beverly Hills, CA 90210

CONFIRMATION NO. 7127
FILING RECEIPT



Date Mailed: 08/16/2017

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Eric Sommerlade, Oxford, UNITED KINGDOM;

Applicant(s)

Eric Sommerlade, Oxford, UNITED KINGDOM;

Power of Attorney:

Penny Lowry--57186

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: 08/15/2017

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 62/543,587**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

Generating reference data for adjusting an image of a head region

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

page 1 of 3

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 Assets Control, 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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	409000A
		Application Number	
Title of Invention	Generating reference data for adjusting an image of a head region		
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.)
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Inventor Information:

Inventor 1				
Legal Name				
Prefix	Given Name	Middle Name	Family Name	Suffix
	Eric		Sommerlade	
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service				
City	Oxford	Country of Residence ⁱ	GB	
Mailing Address of Inventor:				
Address 1	100 N. Crescent Drive			
Address 2	Suite 200			
City	Beverly Hills	State/Province	CA	
Postal Code	90210	Country ⁱ	US	
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. Add				

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence Information of this application.			
Customer Number	145234		
Email Address	patpros@reald.com	Add Email	Remove Email

Application Information:

Title of the Invention	Generating reference data for adjusting an image of a head region		
Attorney Docket Number	409000A	Small Entity Status Claimed	☒
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	10	Suggested Figure for Publication (if any)	1012 - Page 4

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	409000A
		Application Number	
Title of Invention	Generating reference data for adjusting an image of a head region		

Filing By Reference:

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

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

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

Publication Information:

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

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

Representative Information:

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

Please Select One:						
☒ Customer Number		☐ US Patent Practitioner		☐ Limited Recognition (37 CFR 11.9)		
Customer Number		145234				
Prefix	Given Name	Middle Name	Family Name	Suffix	Remove	
Registration Number						
Prefix	Given Name	Middle Name	Family Name	Suffix	Remove	
Registration Number						
Additional Representative Information blocks may be generated within this form by selecting the Add button.						

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	409000A
		Application Number	
Title of Invention	Generating reference data for adjusting an image of a head region		

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 this 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 blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.			

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) 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).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ^l (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			

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.

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	409000A
	Application Number	
Title of Invention	Generating reference data for adjusting an image of a head region	

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.

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	409000A
		Application Number	
Title of Invention	Generating reference data for adjusting an image of a head region		

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									
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. ☐									
Prefix	Given Name	Middle Name	Family Name	Suffix					
Mailing Address Information For Applicant:									
Address 1									
Address 2									
City		State/Province							
Country ¹		Postal Code							
Phone Number		Fax Number							
Email Address									
Additional Applicant Data may be generated within this form by selecting the Add button.									

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	409000A
		Application Number	
Title of Invention	Generating reference data for adjusting an image of a head region		

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.

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.							
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.							

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	409000A
		Application Number	
Title of Invention	Generating reference data for adjusting an image of a head region		

Signature:

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	/Penny L. Lowry/			Date (YYYY-MM-DD)	
First Name	Penny L.	Last Name	Lowry	Registration Number	57186
Additional Signature may be generated within this form by selecting the Add button.					

Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

Inventor(s)

Inventor 1

[Remove](#)

Given Name

Middle Name

Family Name

City

State

Country ;

Eric

Sommerlade

Oxford

GB

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

[Add](#)

Title of Invention

Method and system for improved facial visual data editing using machine learning

Attorney Docket Number (if applicable)

409000A

Correspondence Address

Direct all correspondence to (select one):

☒ The address corresponding to Customer Number

☐ Firm or Individual Name

Customer Number

145234

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:

Yes, the invention was under a contract with an agency of the United States Government. The name of the U.S. Government agency and Government contract number are:

Entity Status

Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29

- ☒ Applicant asserts small entity status under 37 CFR 1.27
- ☐ Applicant certifies micro entity status under 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
- ☐ No

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 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.

Signature

Please see 37 CFR 1.4(d) for the form of the signature.

Signature	Penny L. Lowry/			Date (YYYY-MM-DD)	2017-08-10
First Name	Penny L.	Last Name	Lowry	Registration Number (If appropriate)	57186

This collection of information is required by 37 CFR 1.51. 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 8 hours 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. **This form can only be used when in conjunction with EFS-Web. If this form is mailed to the USPTO, it may cause delays in handling the provisional application.**

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

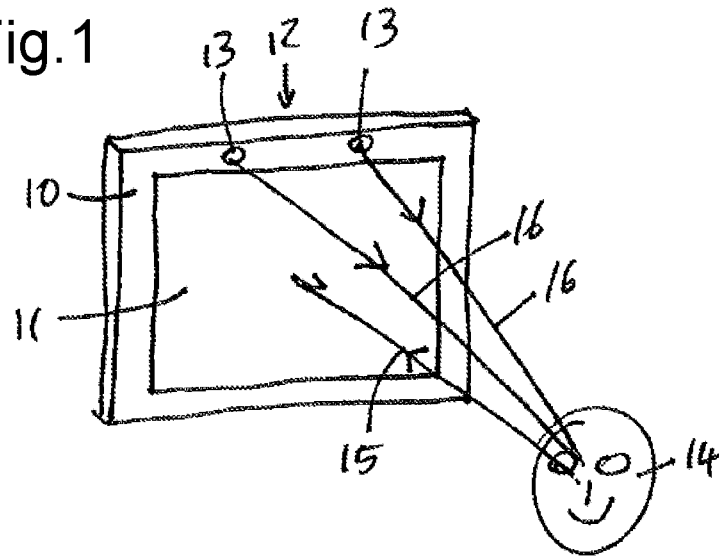


Fig. 2

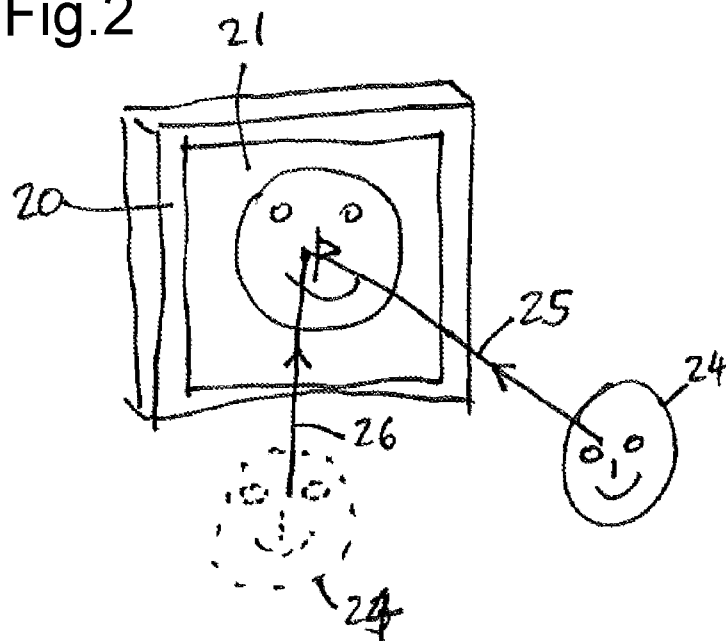


Fig. 3

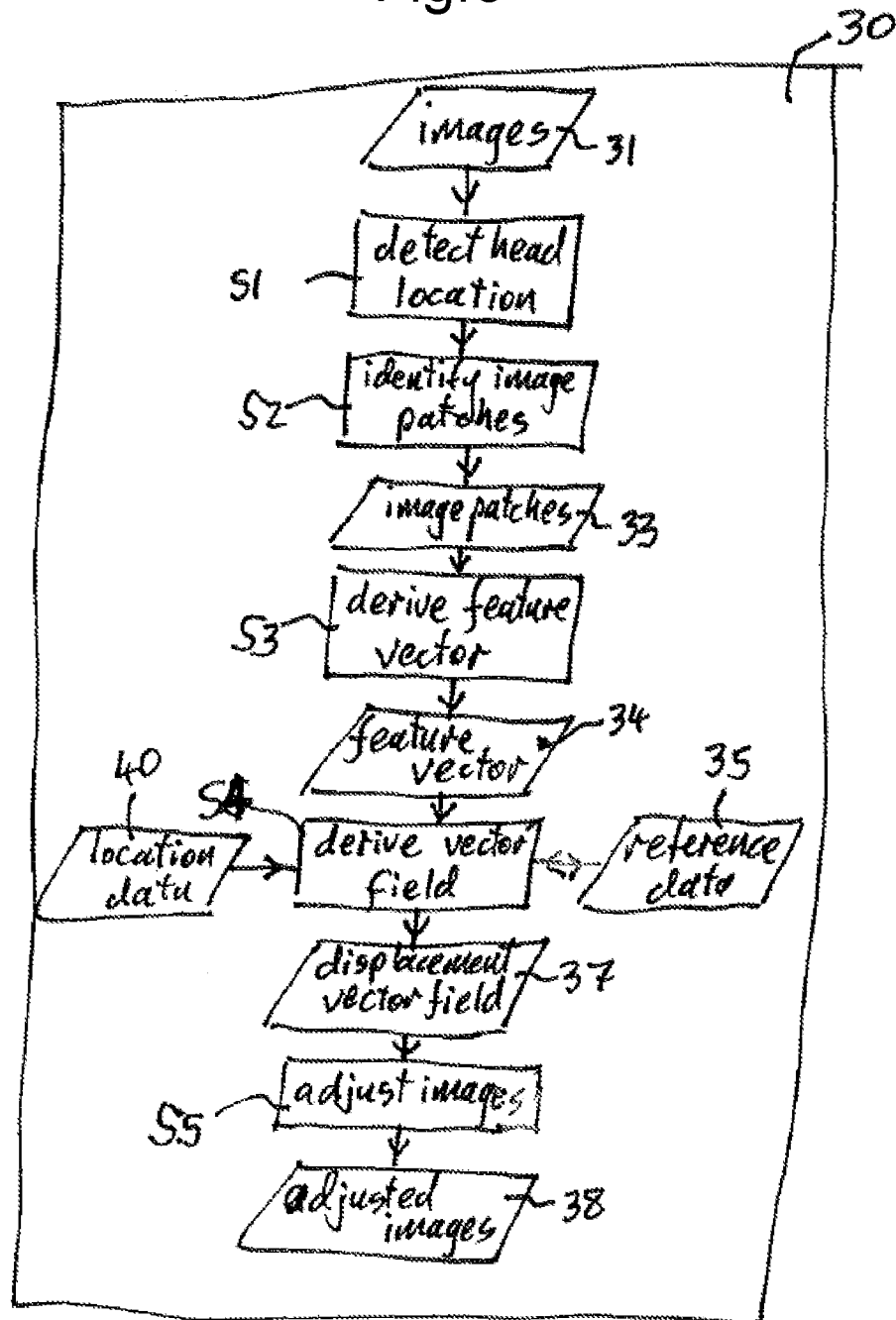


Fig.4

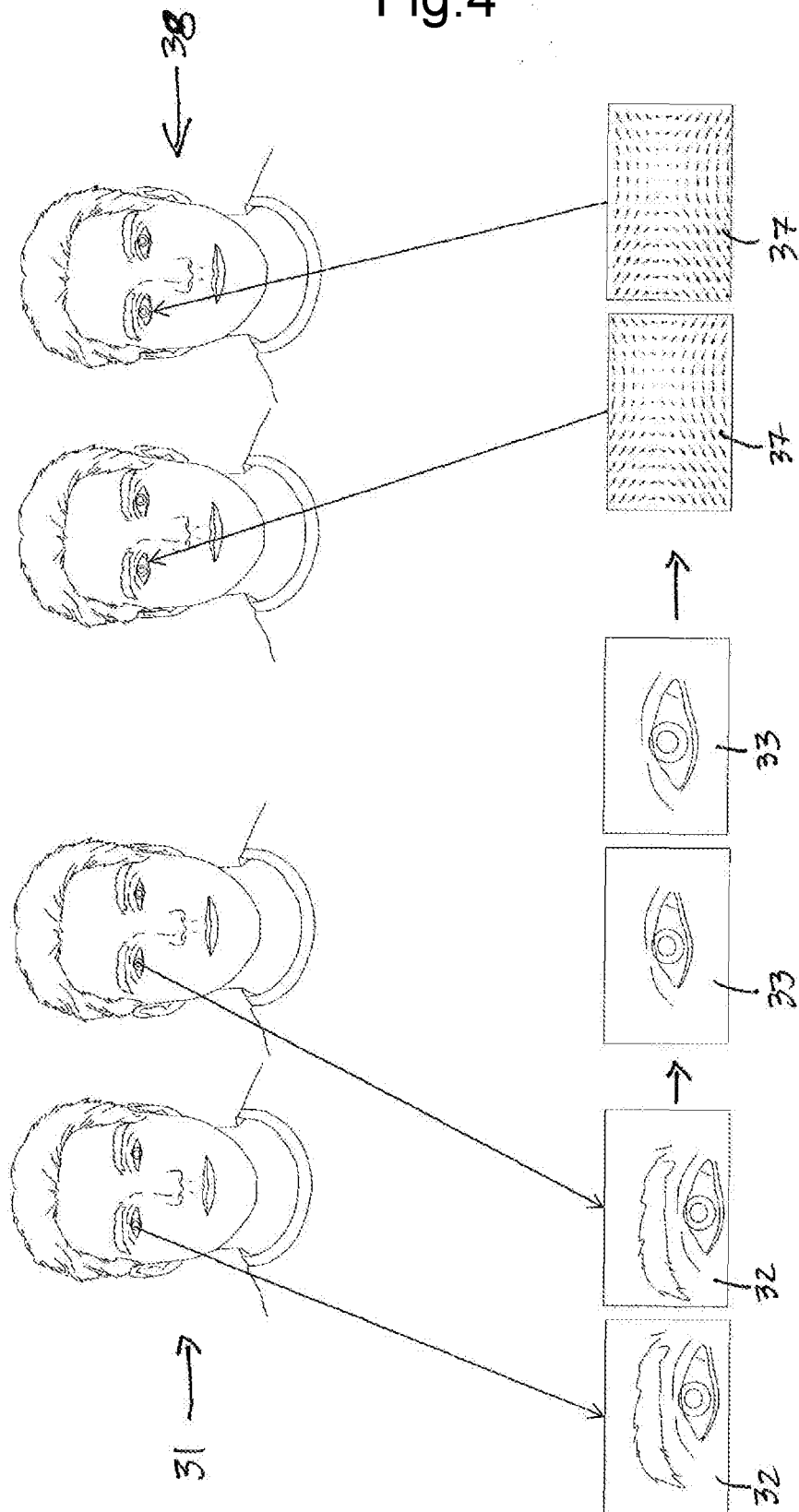


Fig.5

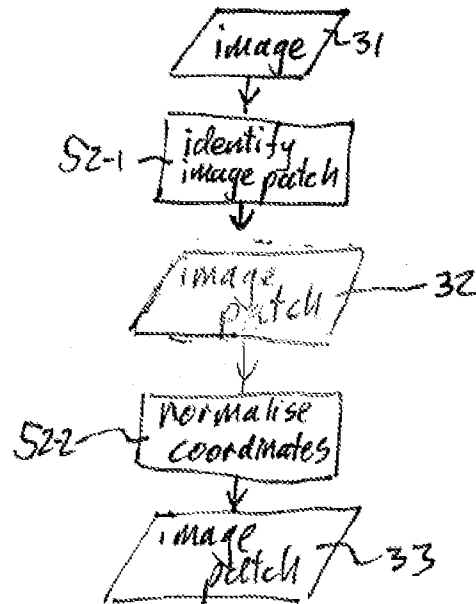


Fig.6

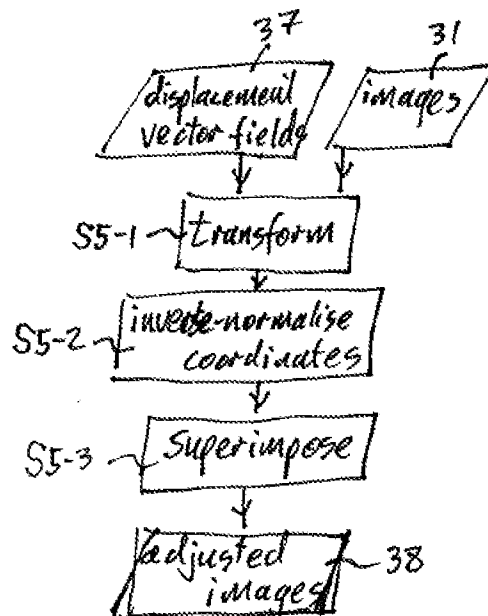


Fig. 7

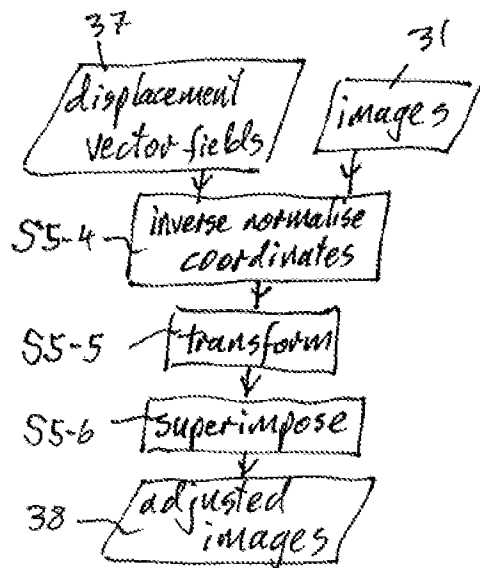


Fig.8

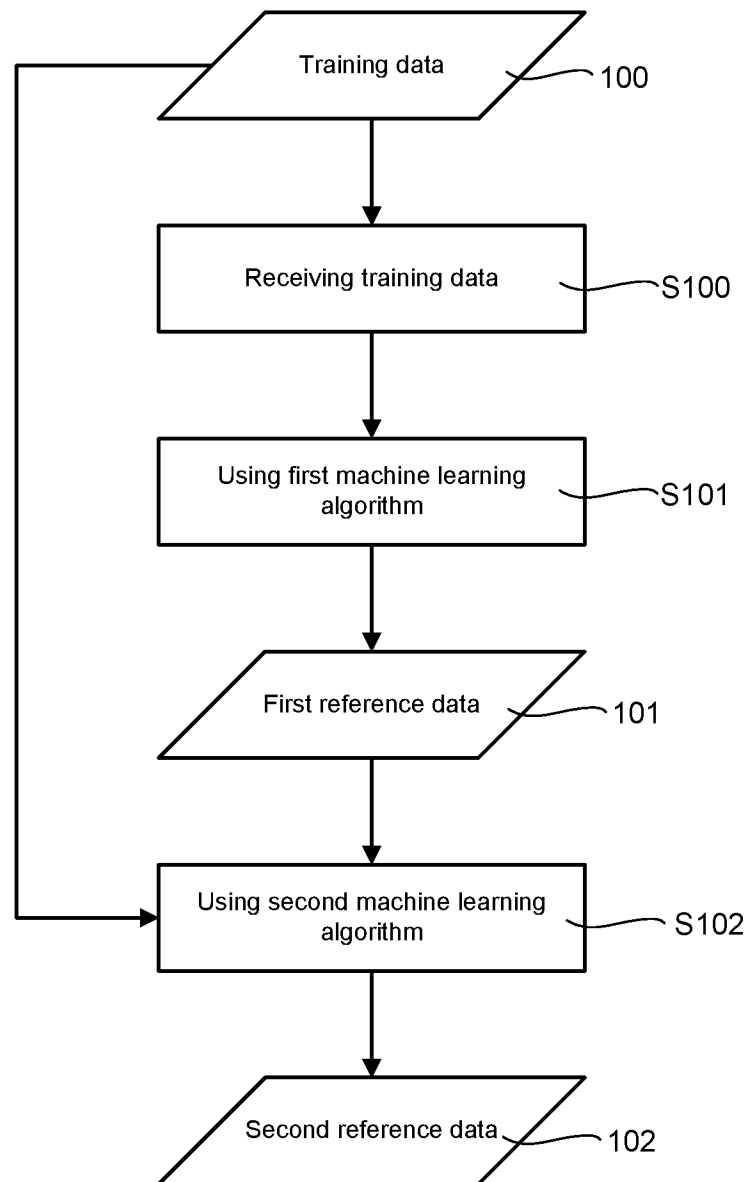


Fig.9

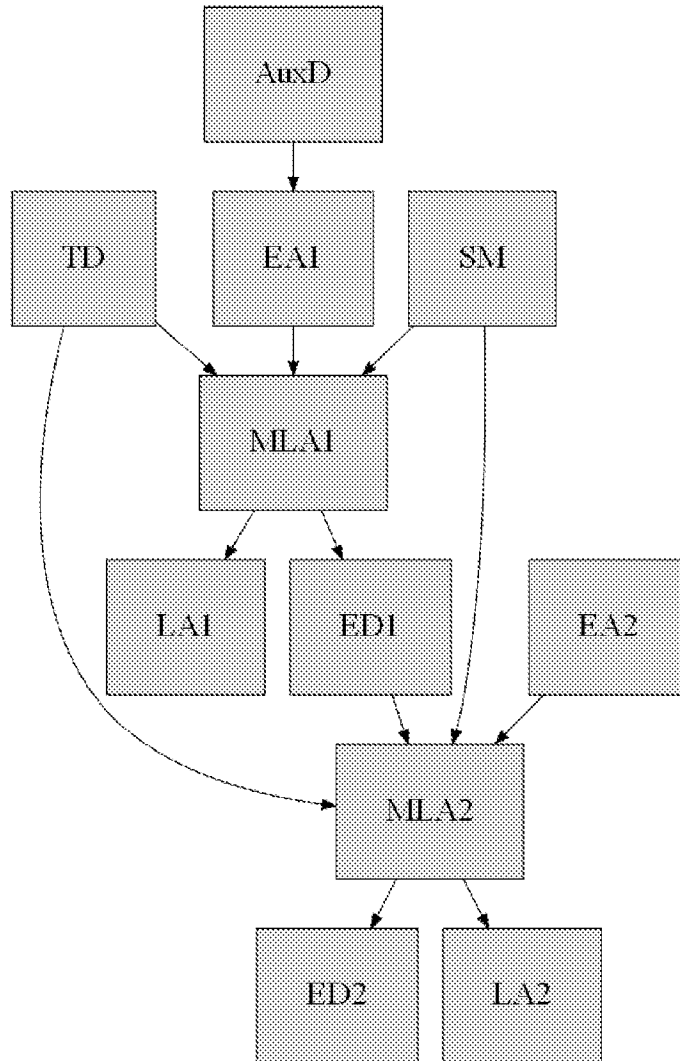


Fig.10

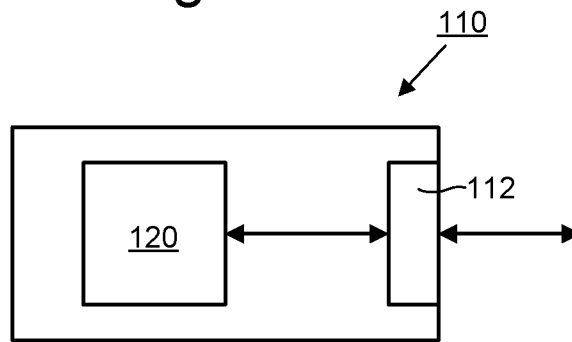


Fig.11

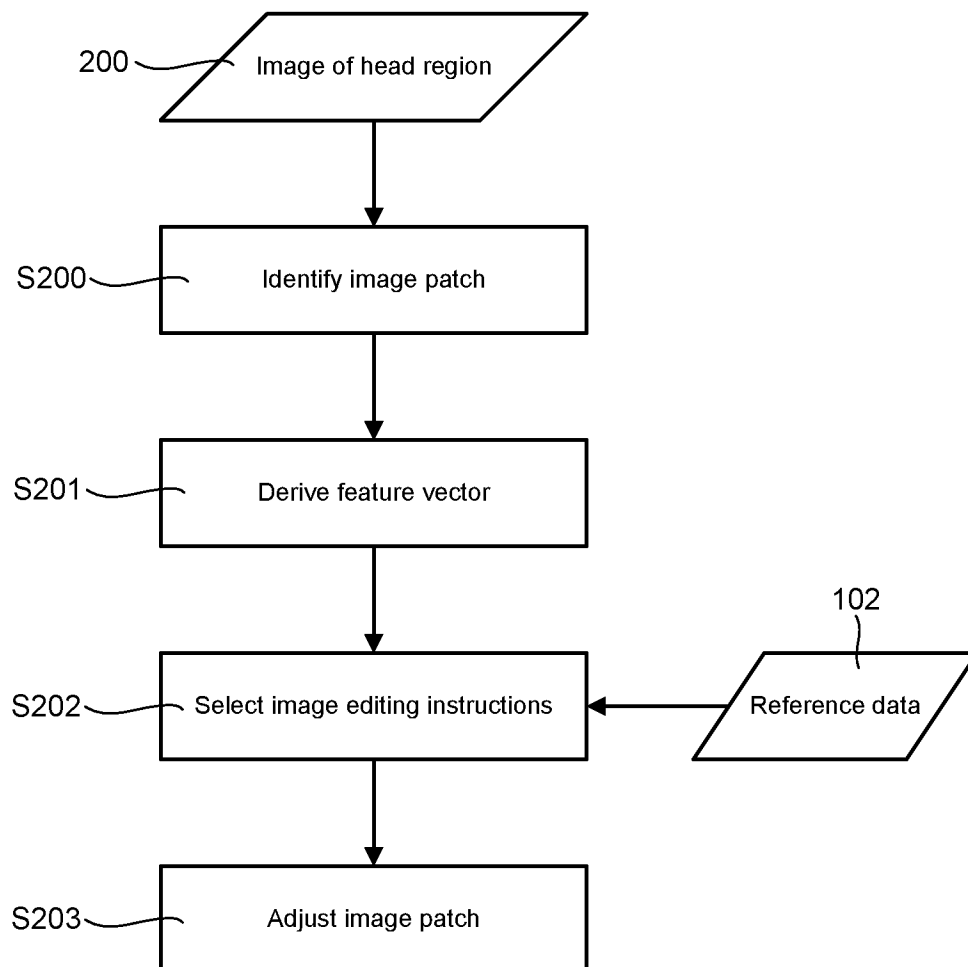


Fig.12

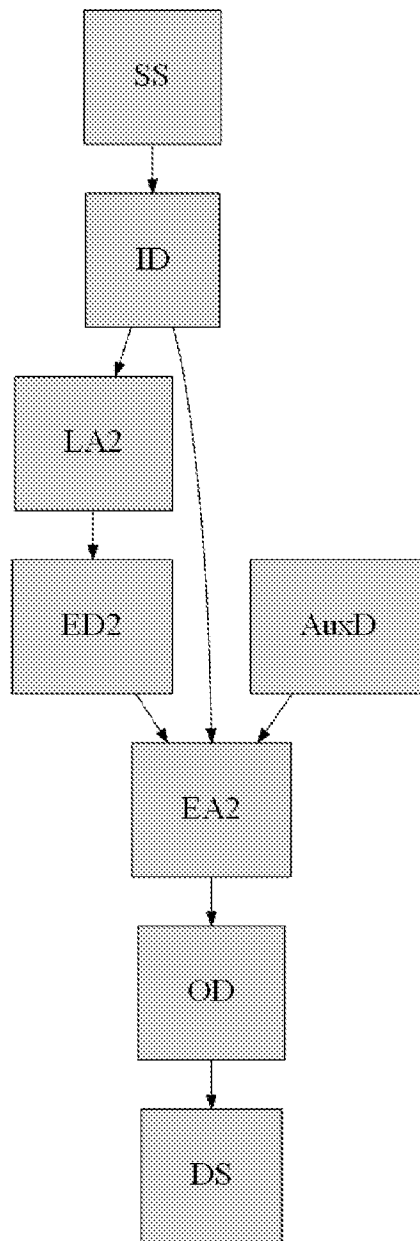
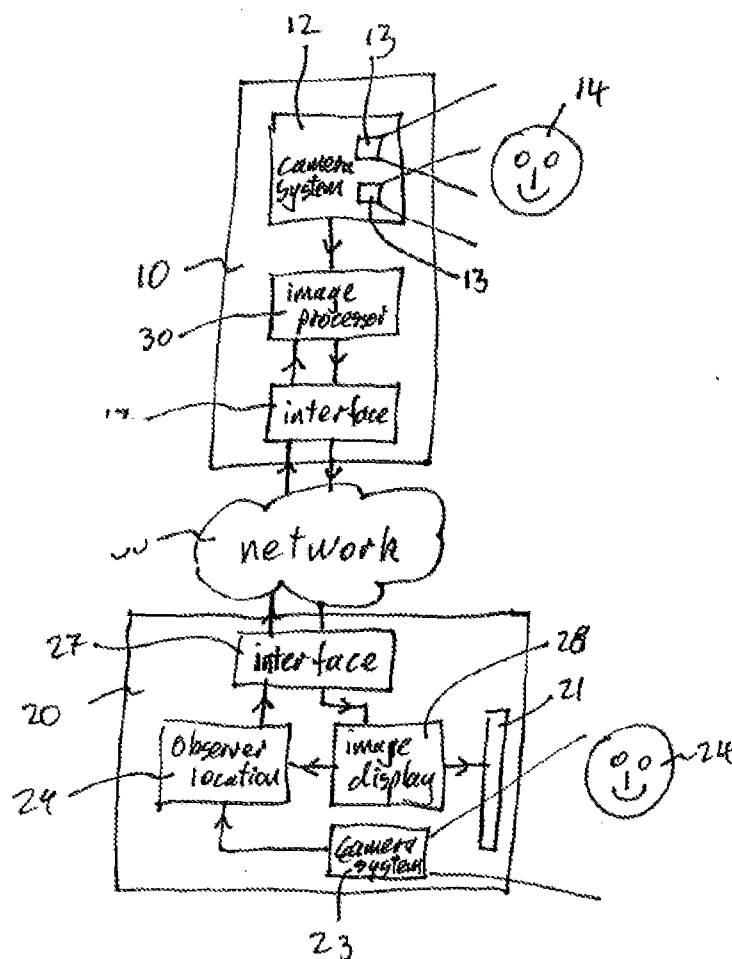


Fig. 13



Generating Reference Data for Adjusting an Image of a Head Region

TECHNICAL FIELD

[01] This application relates to generating reference data for adjusting an image of a head region, particularly a facial and/or neck region, and to adjusting an image of a head region using the reference data or other reference data. The application relates particularly to adjusting target features of the image of the head region, for example to correct a perceived gaze direction of eyes, or to modify the texture and/or shape of features such as the nose, mouth, chin or neck.

BACKGROUND

[02] In many systems, images of a head, which may comprise single images at different times, or stereoscopic pairs of images or other multi-view images, may be captured in one device and displayed on a different device for viewing by an observer. One non-limitative example is a system for performing teleconferencing between two telecommunications devices. In that case, each device may capture images of the observer of that device and transmit them to the other device over a telecommunications network for display and viewing by the observer of the other device.

[03] When an image of a head is captured and displayed, the gaze of the head may not be directed at the observer. This may be caused for example by the gaze of the head not being directed at the camera system used to capture the image, for example because the user whose head is imaged is observing a display in the same device as the camera system and the camera system is offset above (or below) that display. In that case, the gaze in the displayed images will be perceived to be downwards (or upwards). The human visual system has evolved high sensitivity to gaze during social interaction, using cues gained from the relative position of the iris and white sclera of other observers. Errors in the perceived gaze are disconcerting. For example in a system for performing teleconferencing, errors in the perceived gaze can create unnatural interactions between the users.

[04] The present disclosure is concerned with image processing techniques for adjusting images of a head region to correct the perceived gaze and/or to improve other aspects of the images. The present disclosure is particularly concerned with implementing such image processing techniques in real time with minimal demands on computer hardware and/or power.

BRIEF SUMMARY

[05] According to a first aspect of the present disclosure, there is provided a method of generating reference data for adjusting an image of a head region, the method comprising: receiving training data comprising: a set of input image patches, each input image patch comprising a target feature of an image of a head region prior to adjustment of the image of the head region, wherein the target feature is the same for each input image patch; and a set of output image patches in one-to-one correspondence with the input image patches, each output image patch comprising the target feature of the image of the head region after adjustment of the image of the head region; using a first machine learning algorithm to generate first reference data using the training data, the first reference data comprising image editing instructions for adjusting the image of the head region for a range of possible images of the head region; and using a second machine learning algorithm to generate second reference data using the same training data as the first machine learning algorithm and the first reference data generated by the first machine learning algorithm, the second reference data comprising image editing instructions for adjusting the image of the head region for a range of possible images of the head region.

[06] The described use of two machine learning algorithms allows an improved balance to be achieved between accuracy of the adjustment process and speed of execution. The first machine learning algorithm can be configured to provide highly detailed first reference data, which provides high accuracy. Use of this first reference data directly in an image processing technique to adjust an image of a head region would be relatively expensive in terms of computational resources because of the high level of detail. By arranging instead for the first reference data to be provided to a second machine learning algorithm, which provides, based on the first reference data and the original training data, the reference data (the second reference data) that is to be used for the adjustment of the image of the head region, it is possible to benefit to an extent from the high accuracy of the first machine learning algorithm whilst also providing reference data that is less detailed and thus easier to process efficiently when performing the adjustment of the image of the head region. The quality of the reference data provided by the second machine learning algorithm is found to be significantly improved when the second machine learning algorithm is provided with both the first reference data and the training data in comparison to when the second machine learning algorithm is provided only with the training data.

[07] In an embodiment, efficiency is further improved by providing image editing instructions in the second reference data in a compressed representation. The use of a compressed representation reduces data storage and bandwidth requirements during use of the image editing instructions to perform adjustment of an image of a head region.

[08] According to a second aspect of the present disclosure, there is provided a device configured to perform a similar method to the first aspect of the invention.

[09] According to a third aspect of the present disclosure, there is provided a method of adjusting an image of a head region, the method comprising: identifying an image patch in the image of the head region, the image patch comprising a target feature of the image of the head region; deriving a feature vector from plural local image descriptors of the image patch; using the feature vector to select image editing instructions from reference data, the reference data comprising image editing instructions for a range of possible values of the feature vector; and applying the selected image editing instructions to the image patch to adjust the image of the head region, wherein: the image editing instructions in the reference data are provided in a compressed representation.

[10] According to a fourth aspect of the present disclosure, there is provided a device configured to perform a similar method of the third aspect of the invention.

[11] The use of a compressed representation reduces data storage and bandwidth requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

[12] Non-limitative embodiments are illustrated by way of example in the accompanying figures, in which like reference numbers indicate similar parts, and in which:

[13] **FIGURE 1** is a schematic perspective view of a device that captures a stereoscopic pair of images;

[14] **FIGURE 2** is a schematic perspective view of a device that displays the stereoscopic pair of images;

[15] **FIGURE 3** is a flow chart of a method of adjusting a stereoscopic pair of images;

[16] **FIGURE 4** is a diagram illustrating the processing of the stereoscopic pair of images in the method of FIGURE 3;

[17] **FIGURE 5** is a flow chart of a step of extracting an image patch;

[18] **FIGURE 6** and **FIGURE 7** are flow charts of two alternatives for a step of adjusting an image;

[19] **FIGURE 8** is flow chart of a method of generating reference data;

[20] **FIGURE 9** schematically depicts data flow in an example method of generating reference data;

[21] **FIGURE 10** depicts a device for generating reference data;

[22] **FIGURE 11** is a flow chart of a method of adjusting an image of a head region;

[23] **FIGURE 12** schematically depicts data flow in an example of a method of adjusting an image of a head region;

[24] **FIGURE 13** is a diagram of a telecommunications system in which the method may be implemented.

DETAILED DESCRIPTION

[25] **FIGURE 1** and **FIGURE 2** illustrate how incorrect gaze is perceived when a stereoscopic pair of images of a head is captured by the device 10 shown in **FIGURE 1** which will be referred to as the source device 10 and displayed on a different device 20 shown in **FIGURE 2** which will be referred to as the destination device 20. Capturing of a stereoscopic pair of images is shown as an example. A similar effect can occur when a monocular image is captured and when more than two views of the head are captured.

[26] The capture device 10 includes a display 11 and a camera system 12. In this particular example, the camera system comprises two cameras 13 in order to capture the stereoscopic pair of images of the head of a source observer 14. In a monocular implementation a single camera may be provided instead of the two cameras 13. The source observer 14 views the display 11, along line 15. The cameras 13 of the camera system 12 are offset from the display 11, in this case being above the display 11. Thus, the cameras 13 effectively look down on the source observer 14 along line 16.

[27] The display device 20 includes a display 21, which in this example can be a stereoscopic display of any known type, for example an autostereoscopic display of any known type. The display 21 displays the stereoscopic pair of images as captured by the capture device 10. A destination observer 24 views the display 21. If the destination observer 24 is located in a normal viewing position perpendicular to the center of the display 21, as shown by the hard outline of the destination observer 24, then the gaze of the source observer 14 is perceived by the

destination observer 24 to be downwards, rather than looking at the destination observer 24, because the cameras 13 of the source device 10 look down on the source observer 14.

[28] Although the cameras 13 are above the display 11 in this example, the cameras 13 could in general could be in any location adjacent the display 11, and the gaze of the source observer 14 perceived by the destination observer 24 would be correspondingly incorrect.

[29] If the destination observer 24 is located in an offset viewing position, as shown by the dotted outline of the destination observer 24 so that the destination observer 24 views the display 21 along line 26, then the offset of the destination observer 24 creates an additional error in the gaze of the source observer 14 perceived by the destination observer 24. A similar additional error in the perceived gaze of the source observer 14 occurs if the destination observer 24 is located in the normal viewing position along line 25, but the displayed image (or stereoscopic pair of images in this example) is displayed on the display 25 in a position offset from the center of the display 25.

[30] A stereoscopic pair of images is an example of multi-view images where there are two images. Although FIGURE 1 illustrates an example where the camera system 12 includes two cameras 13 that capture of a stereoscopic pair of images, alternatively the camera system may include more than two cameras 13 that capture more than two multi-view images, in which case similar issues of incorrect perceived gaze exist on display. The camera system may alternatively include only one camera.

[31] **FIGURE 3** illustrates a method of adjusting multi-view images to correct such errors in the perceived gaze. The method of a FIGURE 3 is a specific example of a method of adjusting images of a head region in the case where the images comprise one or more multi-view images of the head region. For simplicity, this method will be described with respect to the adjustment of multi-view images comprising a stereoscopic pair of images. The method may be generalized to multi-view images comprising more than two images, simply by performing the similar processing on a larger number of images. The method may also be generalized to the case where single view (monocular) images of the head region are used.

[32] The method may be performed in an image processor 30. The image processor 30 may be implemented by a processor executing a suitable computer program or by dedicated hardware or by some combination of software and hardware. Where a computer program is used, the computer program may comprise instructions in any suitable language and may be stored on a

computer readable storage medium, which may be of any type, for example: a recording medium which is insertable into a drive of the computing system and which may store information magnetically, optically or opto-magnetically; a fixed recording medium of the computer system such as a hard drive; or a computer memory.

[33] The image processor 30 may be provided in the source device 10, the destination device 10 or in any other device, for example a server on a telecommunications network, which may be suitable in the case that the source device 10 and the destination device 10 communicate over such a telecommunications network.

[34] In this example, a stereoscopic pair of images 31 are captured by the camera system 12. Although the camera systems 12 is illustrated in FIGURE 1 as including two cameras 13, this is not limitative and more generally the camera system 13 may have the following properties.

[35] The camera system comprises a set of one or more cameras 13, with at least two cameras 13 in the case where multi-view images are processed. Where two cameras are provided, the cameras are typically spaced apart by a distance less than the average human intrapupilar distance. In the alternative that the method is applied to more than two multi-view images, then there are more than two cameras 13, that is one camera 13 per image.

[36] Where plural cameras 13 are provided, the cameras 13 are spatially related to each other and the display 11. The spatial relationship between the cameras 13 themselves and between the cameras 13 and the display 11 is known in advance. Known methods for finding the spatial relationship may be applied, for example a calibration method using a reference image, or specification *a priori*.

[37] The camera or cameras 13 face in the same direction as the display 11. Thus, when the source observer 14 is viewing the display 11, then the camera or cameras 13 face the source observer 14 and the captured image or images (e.g. stereoscopic pair of images) are images of the head of the source observer 14. Different cameras in the camera system can have different fields of view.

[38] The camera system 12 may include cameras 13 having different sensing modalities, including visible light and infrared.

[39] The main output of the camera system 13 is images 31 which are typically video images output at a video rate. The output of the camera system 13 may also include data representing the spatial relationship between the cameras 13 and the display 11, the nature of the sensing

modalities and internal parameters of the cameras 13 (for example focal length, optical axis) which may be used for angular localization.

[40] An example of the method performed on a stereoscopic pair of images 31, for the case of adjustment of eye regions, is as follows. To illustrate this example method, reference is also made to **FIGURE 4** which shows an example of the stereoscopic pair of images 31 at various stages of the method.

[41] In step S1, the stereoscopic pair of images 31 are analyzed to detect the location of the head and in particular the eyes of the source observer 14 within the stereoscopic pair of images 31. This is performed by detecting presence of a head, tracking the head, and localizing the eyes of the head. Step S1 may be performed using a variety of techniques that are known in the art.

[42] One possible technique for detecting the presence of the head is to use Haar feature cascades, for example as disclosed in Viola and Jones, "Rapid Object Detection using a Boosted Cascade of Simple Features", CVPR 2001, pp 1-9 (incorporated herein by reference).

[43] One possible technique for tracking the head is to use the approach of Active Appearance Models to provide the position of the head of the subject, as well as the location of the eyes, for example as disclosed in Cootes et al., "Active shape models - their training and application", Computer Vision and Image Understanding, 61(1):38-59, Jan. 1995 and in Cootes et al. "Active appearance models", IEEE Trans. Pattern Analysis and Machine Intelligence, 23(6):681-685, 2001 (incorporated herein by reference).

[44] In step S1, typically, a set of individual points ("landmarks") are set to regions of the face, typically the eyes, for example corners of the eye, upper and lower lid locations, etc, thereby localizing the eyes.

[45] In step S2, image patches containing the left and right eyes of the head, respectively are identified in each image 31 of the stereoscopic pair. **FIGURE 4** shows the identified image patches 32 of the right eye in each image 31 (the image patches for the left eye being omitted in **FIGURE 4** for clarity).

[46] Step S2 may be performed as shown in **FIGURE 5**, as follows.

[47] In step S2-1, image patches 32 containing the left and right eyes of the head are identified in each image 31 of the stereoscopic pair. This is done by identifying an image patch 39 in each image 31 located around the identified points ("landmarks") corresponding to features of an eye, as shown for example in **FIGURE 4**.

[48] In step S2-2, the image patches 32 identified in step S2-1 are transformed into a normalized coordinate system, being the same normalized coordinate system as used in the machine learning process which is described further below. The transformation is chosen to align the points (“landmarks”) of the eye within the image patch that were identified in step S1, with predetermined locations in the normalized coordinate system. The transformation may include translation, rotation and scaling, to appropriate extents to achieve that alignment. The output of step S2-2 is identified image patches 33 of the right eye in each image in the normalized coordinate system as shown for example in FIGURE 4.

[49] The following steps are performed separately (a) in respect of the image patches containing the left eyes of the head in each image 31 of the stereoscopic pair, and (b) in respect of the image patches containing the right eyes of the head in each image 31 of the stereoscopic pair (in this example). For brevity, the following description will refer merely to image patches and eyes without specifying the left or right eye, but noting the same steps are performed for both left and right eyes.

[50] In step S3, a feature vector 34 is derived from plural local image descriptors of an image patch 33 in at least one image 31 of the stereoscopic pair (in this example). Depending on the approach and as described further below, this may be an image patch in a single image 31 of the stereoscopic pair or may be both images 31 of the stereoscopic pair. Thus, the local image descriptors are local image descriptors derived in the normalized coordinate system.

[51] The feature vectors 34 are representations of the image patches 33 that are suitable for use in looking up reference data 35 to be used for adjusting the image patches. The reference data 35 may comprise reference displacement vector fields that represent transformations of the image patch, or other representations of transformations of the image patch, including compressed representations as described below, and are associated with possible values of the feature vector.

[52] The reference data 35 is obtained and analyzed in advance using a machine learning technique. The machine learning technique may derive the form of the feature vectors 34 and associate transformations such as the reference displacement vector fields with the possible values of the feature vector. A specific example of a machine learning technique applied in the case where it is desired to correct gaze will now be described before reverting to the method of FIGURE 3.

[53] The training input to the machine learning technique is two sets of images (or image patches), which may be stereoscopic pairs of images or monoscopic images, as discussed further below. Each set may comprise images of the head of the same group of individuals but captured from cameras in different locations relative to the gaze so that the perceived gaze differs as between them (in the case where gaze is to be corrected).

[54] The first set are input images, being images of each individual with an incorrect gaze where the error is known *a priori*. In particular, the images in the first set may be captured by at least one cameras in a known camera location where the gaze of the individual which is in a different known direction. For example in the case of the source device of FIGURE 1, the camera location may be the location of a camera 13 and while the gaze of the imaged individual is towards the center of the display 11.

[55] The second set are output images, being images of each individual with correct gaze for a predetermined observer location relative to a display location in which the image is to be displayed. In the simplest case, the observer location is a normal viewing position perpendicular to the center of the display location, for example as shown by the hard outline of the destination observer 24 in the case of the destination device 20 of FIGURE 2.

[56] For each image in the two sets, the image is analyzed to detect the location of the head and in particular the eyes using the same technique as used in step S1 described above, and then image patches containing the left and right eyes of the head, respectively, are identified using the same technique as used in step S2 described above. The following steps are then performed separately (a) in respect of the image patches containing the left eyes of the head in each image, and (b) in respect of the image patches containing the right eyes of the head in each image. For brevity, the following description will refer merely to image patches and eyes without specifying the left or right eye, but noting the same steps are performed for both left and right eyes in this embodiment.

[57] Each image patch is transformed into the same normalized coordinate system as used in step S2 described above. As described above, the transformation is chosen to align points (“landmarks”) of the eye with predetermined locations in the normalized coordinate system. The transformation may include translation, rotation and scaling, to appropriate extents to achieve that alignment.

[58] Thus, the image patches input and output images of each individual are aligned in the

normalized coordinate system.

[59] From an input and output image of each individual, there is derived a displacement vector field that represents the transformation of the image patch in the input image required to obtain the image patch of the output image, for example as follows. Defining positions in the image patches by (x,y) , the displacement vector field $\mathbf{F}$ is given by

$$\mathbf{F}=\{u(x, y), v(x, y)\}$$

where u and v define the horizontal and vertical components of the vector at each position (x,y) .

[60] The displacement vector field $\mathbf{F}$ is chosen so that the image patch of the output image $O(x,y)$ is derived from the image patch of the input image $I(x,y)$ as

$$O(x, y) = I(x+u(x, y), y+v(x,y))$$

[61] For image data from more than one camera, the system delivers a displacement vector field for the input image from each camera.

[62] The displacement vector field $\mathbf{F}$ for an input and output image of an individual may be derived using a process in which a trial feature vector $\mathbf{F}'=\{u',v'\}$ is modified to minimize error, optionally in an iterative process, for example in accordance with:

$$\sum |O(x, y) - I(x + u'(x, y), y + v'(x, y))| = \min!$$

[63] By way of non-limitative example, the displacement vector field $\mathbf{F}$ may be derived as disclosed in Kononenko et al., “Learning To Look Up: Realtime Monocular Gaze Correction Using Machine Learning”, Computer Vision and Pattern Recognition, 2015, pp. 4667-4675 (incorporated herein by reference), wherein the displacement vector field $\mathbf{F}$ is referred to as a “flow field”.

[64] Another example for image editing instructions, which can be used additionally or as an alternative to the displacement vector field in any of the arrangements disclosed herein, is given by filter field $L = \{k(P, x, y)\}$, which defines a filter kernel for a given location (x, y) . This filter field L is chosen so that the image patch of the output image $O(x, y)$ is derived from the image patch of the input image $I(x, y)$ as $O(x, y) = k(P(I, x, y), x, y)$, where $P(I, x, y)$ is a local region around the point (x,y) in the image I , and $k(P, x, y)$ operates on the patch P with coefficients depending on the position (x, y) . For example, it could be the output of a convolution of the patch with a Gaussian filter with width depending on the position x in the image, or a brightness increase of a local pixel depending on the vertical position y .

[65] Another example for image editing instructions which, can be used additionally or as an

alternative to the displacement vector field in any of the arrangements disclosed herein, is given by a set of typical image components that make up the edited image area, e.g. texture showing beard stubbles. These are then blended with a factor depending on the image coordinates and local image content (i.e. a texture blending field). Other transformation fields can be used, such as a brightness adjustment field.

[66] A machine learning technique is used to obtain a map from the displacement vector field $\mathbf{F}$ (or other image editing instructions) of each individual to respective feature vectors derived from plural local image descriptors of the image patch of the input image.

[67] The local descriptors capture relevant information of a local part of the image patch of the input image and the set of descriptors usually form a continuous vectorial output.

[68] The local image descriptors input into the machine learning process are of types expected to provide discrimination between different individuals, although the specific local image descriptors are selected and optimized by the machine learning process itself. In general, the local image descriptors may be of any suitable type, some non-limitative examples which may be applied in any combination being as follows.

[69] The local image descriptors may include values of individual pixels or a linear combination thereof. Such a linear combination may be, for example, a difference between the pixels at two points, a kernel derived within a mask at an arbitrary location, or a difference between two kernels at different locations.

[70] The local image descriptors may include distances of a pixel location from the position of an eye point (“landmark”).

[71] The local image descriptors may include SIFT features (Scale-invariant feature transform features), for example as disclosed in Lowe, “Distinctive Image Features from Scale-Invariant Keypoints”, International Journal of Computer Vision 60 (2), pp 91–110 (incorporated herein by reference).

[72] The local image descriptors may include HOG features (Histogram of Oriented Gradients features), for example as disclosed in Dalal et al. “Histograms of Oriented Gradients for Human Detection”, Computer Vision and Pattern Recognition, 2005, pp. 886-893 (incorporated herein by reference).

[73] The local image descriptors may include “low level representations” from pre-classification stages in deep learning neural networks, for example as disclosed in Yang and

Ramanan, “Multi-scale recognition with DAG-CNNs”, ICCV 2015. In a classifying deep learning neural network with multiple layers applied to an input image, for example, such low level features could be taken from a layer before the final classification layer of the network.

[74] The derivation of the feature vector from plural local image descriptors depends on the type of machine learning applied.

[75] In a first type of machine learning technique, the feature vector may comprise features that are values derived from the local image descriptors in a discrete space, being binary values or values discretized into more than two possible values. In this case, the machine learning technique associates a reference displacement vector field $\mathbf{F}$ derived from the training input with each possible value of the feature vector in the discrete space, so the reference data 35 is essentially a look-up table. This allows a reference displacement vector field $\mathbf{F}$ to be simply selected from the reference data 35 on the basis of the feature vector 34 derived in step S3, as described below.

[76] In the case that the feature vector comprises features that are binary values derived from the local image descriptors, the feature vector has a binary representation. Such binary values may be derived in various ways from the values of descriptors, for example by comparing the value of a descriptor with a threshold, comparing the value of two descriptors, or by comparing the distance of a pixel location from the position of an eye point (“landmark”).

[77] Alternatively, the feature vector may comprise features that are discretized values of the local image descriptors. In this case, more than two discrete values of each feature are possible.

[78] Any suitable machine learning technique may be applied, for example using a decision tree, a decision forest, a decision fern or an ensemble or combination thereof, or a neural network.

[79] By way of example, a suitable machine learning technique using a feature vector comprising features that are binary values derived by comparing a set of individual pixels or a linear combination thereof against a threshold, is disclosed in Ozuysal et al. “Fast Keypoint Recognition in Ten Lines of Code”, Computer Vision and Pattern Recognition, 2007, pp. 1-8 (incorporated herein by reference).

[80] By way of further example, a suitable machine learning technique using a distance of a pixel location with the position of an eye landmark is disclosed in Kononenko et al., “Learning To Look Up: Realtime Monocular Gaze Correction Using Machine Learning”, Computer Vision

and Pattern Recognition, 2015, pp. 4667-4675 (incorporated herein by reference).

[81] By way of further example, a suitable machine learning technique using a random decision forest is disclosed in Ho, “Random Decision Forests”, Proceedings of the 3rd International Conference on Document Analysis and Recognition, Montreal, QC, 14–16 August 1995, pp. 278-282 (incorporated herein by reference).

[82] In a second type of machine learning technique, the feature vector may comprise features that are discrete values of the local image descriptors in a continuous space. In this case, the machine learning technique associates a reference displacement vector field $\mathbf{F}$ (in this example, but other image editing instructions could be used) derived from the training input with possible discrete values of the feature vector in the continuous space. This allows a displacement vector field $\mathbf{F}$ to be derived from the reference data 35 by interpolation from the reference displacement vector fields based on the relationship between the feature vector 34 derived in step S3 and the values of the feature vector associated with the reference displacement vector fields.

[83] Any suitable machine learning technique may be applied, for example using support vector regression.

[84] By way of example, a suitable machine learning technique using support vector regression is disclosed in Drucker et al. “Support Vector Regression Machines”, Advances in Neural Information Processing Systems 9, NIPS 1996, 155–161, (incorporated herein by reference). The output of the technique is a continuously varying set of interpolation directions that form part of the reference data 35 and are used in the interpolation.

[85] The machine learning technique, regardless of its type, inherently also derives the form of the feature vectors 34 that is used to derive the reference displacement vector fields $\mathbf{F}$ (or other image editing instructions). This is the form of the feature vectors 34 that is derived in step S3.

[86] The description now reverts to the method of FIGURE 3.

[87] In step S4, at least one displacement vector field 37 representing a transformation of an image patch is derived by using the feature vector 34 derived in step S3 is to look up the reference data 35. Due to the derivation of the displacement vector field 37 from the reference data 35, the transformation represented thereby corrects the gaze that will be perceived when the stereoscopic pair of images 31 are displayed.

[88] In the case that the feature vector 34 comprises features that are values in a discrete space and the reference displacement vector fields of the reference data 35 comprise a reference

displacement vector field associated with each possible value of the feature vector in the discrete space, then the displacement vector field for the image patch is derived by selecting the reference displacement field associated with the actual value of the derived feature vector 34.

[89] In the case that the feature vector 34 comprises features that are discrete values of the local image descriptors in a continuous space, then the displacement vector field for the image patch is derived by interpolating a displacement vector field from the reference displacement vector fields based on the relationship between the actual value of the derived feature vector 34 and the values of the feature vectors associated with the reference displacement vector fields. In the case that the machine learning technique was support vector regression, This may be done using the interpolation directions that form part of the reference data 35.

[90] In step S5, each image 31 of the stereoscopic pair is adjusted by transforming the image patches containing the left and right eyes of the head in accordance with the derived displacement vector fields 37. This produces an adjusted stereoscopic pair of images 38 as shown in FIGURE 4, in which the gaze has been corrected. In particular, the adjustment may be performed using two alternative methods, as follows.

[91] A first method for performing step S5 is shown in **FIGURE 6** and performed as follows.

[92] In step S5-1, the image patch is transformed in the normalised coordinate system in accordance with the corresponding displacement vector field 37 in respect of the same image, thereby correcting the gaze. As described above, for a displacement vector field $\mathbf{F}$ the transformation of the image patch of the input image $I(x,y)$ provides the output image $O(x,y)$ in accordance with

$$O(x, y) = I(x+u(x, y), y+v(x,y))$$

[93] In step S5-2, the transformed image patch output from step S5-1 is transformed out of the normalised coordinate system, back into the original coordinate system of the corresponding image 31. This is done using the inverse transformation from that applied in step S2-2.

[94] In step S5-3, the transformed image patch output from step S5-2 is superimposed on the corresponding image 31. This may be done with a full replacement within an eye region corresponding to the eye itself, and a smoothed transition between the transformed image patch and the original image 31 over a boundary region around the eye region. The width of the boundary region may be of fixed size or a percentage of the size of the image patch in the original image 31.

[95] A second method for performing step S5 is shown in **FIGURE 7** and performed as follows.

[96] In this second, alternative method, the transformation back into the coordinate system of the corresponding image 31 occurs before the transformation of the image patch in accordance with the transformed displacement vector field **F**.

[97] In step S5-4, the displacement vector field **F** is transformed out of the normalised coordinate system, back into the original coordinate system of the corresponding image 31. This is done using the inverse transformation from that applied in step S2-2.

[98] In step S5-5, the image patch 32 in the coordinate system of the image 31 is transformed in accordance with the displacement vector field **F** that has been transformed into the same coordinate system in step S5-4. As described above, for a displacement vector field **F** the transformation of the image patch of the input image $I(x,y)$ provides the output image $O(x,y)$ in accordance with

$$O(x, y) = I(x+u(x, y), y+v(x,y))$$

but this is now performed in the coordinate system of the original image 31.

[99] Step S5-6 is the same as S5-3. Thus, in step S5-6, the transformed image patch output from step S5-5 is superimposed on the corresponding image 31. This may be done with a full replacement within an eye region corresponding to the eye itself, and a smoothed transition between the transformed image patch and the original image 31 over a boundary region around the eye region. The width of the boundary region may be of fixed size or a percentage of the size of the image patch in the original image 31.

[100] **FIGURE 8** depicts a method of generating reference data (including reference data 37 of the type described in the specific examples discussed above) for adjusting an image of a head region. The method comprises a step S100 of receiving training data 100. The training data 100 may be provided for example via a communications interface 112 (e.g. connecting to an external data connection or storage device) connected to a data processing unit 120 that is to perform the method (as depicted schematically in **FIGURE 10**). The training data 100 comprises a set of input image patches. Each input image patch comprises a target feature of an image of a head region prior to adjustment of the image of the head region. The target feature is the same for each input image patch. The target feature may comprise one or more of the following: an eye region comprising at least part of an eye (as in the specific examples discussed above with

reference to FIGURE 4 for example), a nose region comprising at least part of a nose, a mouth region comprising at least part of a mouth, a chin region comprising at least part of a chin, and a neck region comprising at least part of a neck. In an embodiment each input image patch comprises a portion of the image of the head region corresponding to the target feature, such as the above-mentioned eye region, nose region, mouth region, chin region, or neck region.

[101] In an embodiment, the target feature comprises an eye region comprising at least part of an eye and the adjustment of the image of the head region comprises adjusting a gaze direction.

[102] In an embodiment, the target feature comprises a nose region comprising at least part of a nose and the adjustment of the image of the head region comprises adjusting a shape and/or texture of the nose (e.g. to make nose look smaller and/or slimmer by a fixed proportion, similar to the effect of a “tele lens”).

[103] In an embodiment, the target feature comprises a chin region comprising at least part of a chin and the adjustment of the image of the head region comprises adjusting a shape and/or texture of the chin (e.g. to reduce or remove double chin appearance).

[104] In an embodiment, the target feature comprises a neck region comprising at least part of a neck and the adjustment of the image of the head region comprises adjusting a shape and/or texture of the neck (e.g. to reduce or remove wrinkles).

[105] In an embodiment, the target feature comprises a hair region comprising hair and the adjustment of the image of the head region comprises adjusting a color of the hair (e.g. by a fixed hue).

[106] In the case where the target feature comprises an eye region, the input image patches may be obtained using the methodology described above with reference to steps S2-1 and S2-2, except that stereoscopic pairs of images are not necessarily required. Thus, the input image patches may be obtained by using identified points (“landmarks”) corresponding to features of an eye to locate the relevant region of the image of the head region (e.g. surrounding the eye) and/or transformation of the input image patch into a normalized coordinate system, including alignment of the landmarks with predetermined locations in the normalized coordinate system using translation, rotation and/or scaling.

[107] The training data 100 further comprises a set of output image patches. The output image patches are in one-to-one correspondence with the input image patches. Each output image patch comprises the target feature of the image of the head region after adjustment of the image

of the head region. Thus, in the case where an image of the head region is to be adjusted to correct a gaze direction, each output image patch comprises an eye region that has been adjusted so that the gaze appears to be in the desired direction (e.g. directly towards a destination observer 24).

[108] The method further comprises a step S101 comprising using a first machine learning algorithm to generate first reference data 101 using the training data 100. The first reference data 101 comprises image editing instructions for adjusting the image of the head region for a range of possible images of the head region.

[109] The method further comprises a step S102 comprising using a second machine learning algorithm to generate second reference data 102. The second machine learning algorithm uses the same training data 100 as the first machine learning algorithm in step S101. The second machine learning algorithm further uses the first reference data 101 output by the first machine learning algorithm in step S101. The second reference data 102 comprises image editing instructions for adjusting the image of the head region for a range of possible images of the head region.

[110] In an embodiment, the first reference data 101 comprises first image editing instructions for a range of possible configurations of the target feature (e.g. different gaze directions and/or eye morphologies in the case where the target feature comprises an eye region) and first selection instructions for selecting image editing instructions (from the first image editing instructions) for a particular input image patch based on the configuration of the target feature of the input image patch (e.g. the particular gaze direction and/or particular eye morphology of that input image patch).

[111] In an embodiment, the second reference data comprises second image editing instructions for a range of possible configurations of the target feature and second selection instructions for selecting image editing instructions (from the second image editing instructions) for a particular input image patch based on the configuration of the target feature of the input image patch.

[112] The configuration of the target feature of each input image patch may be represented by a feature vector derived from plural local image descriptors of the input image patch, as described above with reference to step S3 of FIGURE 3 for the particular case where stereoscopic pairs of images containing eye regions are processed (but the method is applicable more generally than this particular case). As described above, the feature vector may take various forms but is

generally adapted to be suitable for looking up image editing instructions for performing adjustment of the image of the head region. In the present embodiment, the first and second selection instructions define how the feature vector is used to select image editing instructions for the input image patch. In an embodiment, the image editing instructions comprise a displacement vector field defining how the input image patch is to be transformed to perform the adjustment. The displacement vector field may take any of the forms discussed above. The image editing instructions are not limited to displacement vector fields, however. Other image editing operations may additionally or alternatively be associated with the features vectors to perform other desired adjustments of the image of the head region, including for example adjustments to pixel colors or intensities, or changes to underlying geometries (e.g. via a filter field, brightness adjustment field, or texture blending field).

[113] In an embodiment, a first image editing algorithm is used by the first machine learning algorithm to define how the first image editing instructions are to be applied to an input image patch to derive an output image patch. A second image editing algorithm is used by the second machine learning algorithm to define how the second image editing instructions are to be applied to an input image patch to derive an output image patch. The first and second image editing algorithms may comprise any of the methods described above for implemented step S5 of FIGURE 3, described with reference to FIGURES 6 and 7.

[114] In an embodiment, the second image editing instructions in the second reference data are provided in a compressed representation. The compressed representation may comprise a principle component analysis representation or a wavelet representation for example. In this case, the first and second image editing algorithms may be adapted to define how to operate efficiently in this context.

[115] In an embodiment, the second image editing instructions are principle component analysis components of a principle component analysis of the first image editing instructions. The second image editing algorithm in this case transforms the second image editing instructions into the first image editing instructions by inverse principle component analysis transform.

[116] In an alternative approach, the second image editing instructions are wavelet components of the first image editing instructions. The second image editing algorithm in this case transforms the second image editing instructions into the first image editing instructions by

inverse wavelet transform.

[117] In an embodiment, the first selection instructions for the first reference data are able to select between a larger number of alternative image editing instructions than the second selection instructions for the second reference data. The first machine learning algorithm may thus be described as having more input parameters than the second machine learning algorithm. The first machine learning algorithm may provide higher accuracy than the second machine learning but will typically operate considerably slower. Additionally, the first selection instructions may be significantly more complex (e.g. involving linear algebra or other relatively computer intensive operations) than the second selection instructions (where the selection instructions may resemble a computationally straightforward look-up table, a combination of a look-up table and a tree structure, or similar).

[118] In one particular embodiment, the first machine learning algorithm comprises a neural network (known to provide relatively high accuracy, but at the expense of relatively high computational demands). In such an embodiment, and others, the second machine learning algorithm may comprises a regression forest (known to provide higher computational efficiency, but at the expense of reduced accuracy). The inventors have found that the combination of the two different machine learning algorithms provides reference data that can be used in an image adjustment method with high efficiency while still achieving high adjustment accuracy. The first machine learning algorithm may alternatively comprise a support vector machine or a generative adversarial network (GAN). The second machine learning algorithm may alternatively comprise regression ferns, cluster centres, a lookup table, or separable filter banks. In one embodiment, the first machine learning algorithm comprises a first neural network and the second machine learning algorithm comprises a second neural network, wherein the second neural network comprises fewer layers and/or smaller convolution fields than the first neural network.

[119] **FIGURE 9** schematically depicts data flow in a detailed example of the method of generating reference data of FIGURE 8. The first and second machine learning algorithms are respectively labelled MLA1 and MLA2. The first machine learning algorithm MLA1 receives the training data (labelled TD) and, optionally, the first machine learning algorithm EA1, and a similarity metric SM. The similarity metric SM provides a numerical value to measure similarity between an adjusted image and a desired image and can be used to control the first machine learning algorithm MLA1 and the second machine learning algorithm MLA2 to vary the extent

to which differences are penalized according to the nature of the differences. For example, the similarity metric SM may be configured to penalize reductions in portions of images that it is desired to maintain (e.g. sclera in the case where eye regions are being adjusted) or deviations of adjusted features from a known form (e.g. deviations in the shape of an iris from an elliptical form) or from a form that is observed in training data. Alternatively or additionally, the training data may comprise an average absolute or square difference between the adjusted image and a target, or average absolute or square difference between low level representations of the adjusted image and target, such as low level features from a deep learning network (as discussed above). In the example shown, the first machine learning algorithm EA1 receives auxiliary data AuxD, which defines a basis set used for providing a compressed representation of image editing instructions. The first machine learning algorithm outputs first selection instructions LA1 and first image editing instructions ED1. The second machine learning algorithm MLA2 receives the same training data TD and, optionally, the second machine learning algorithm EA2, and the similarity metric SM. The second machine learning algorithm MLA2 additionally receives the first image editing instructions ED1. The second machine learning algorithm outputs second selection instructions LA2 and second image editing instructions ED2.

[120] The second machine learning algorithm MLA2 thus gets the editing instructions to match or to approximate, and does not have to infer these from the matched input images as MLA1.

[121] **FIGURE 10** depicts a device 110 for generating the reference data. The device 110 comprises a data processing unit 120 configured to perform the method of generating the reference data according to any of the disclosed embodiments. The data processing unit 110 may be implemented by a processor executing a suitable computer program or by dedicated hardware or by some combination of software and hardware. Data input/output may be provided via a communications interface 112. Where a computer program is used, the computer program may comprise instructions in any suitable language and may be stored on a computer readable storage medium, which may be of any type, for example: a recording medium which is insertable into a drive of the computing system and which may store information magnetically, optically or opto-magnetically; a fixed recording medium of the computer system such as a hard drive; or a computer memory.

[122] **FIGURE 11** depicts a method of adjusting an image of a head region. The method may use reference data generated using any of the methods of generating reference data disclosed

herein or may use reference data generated using other methods.

[123] The method comprises a step S200 in which an image patch is identified in an image 200 of a head region that is to be adjusted. The image patch comprises a target feature of the head region. The target feature may take any of the forms discussed above. The step S200 may optionally comprise detecting a head and/or eye location as described above with reference to step S1 of FIGURE 3. The step S200 may optionally further comprise identifying image patches using the methodology described above with reference to steps S2-1 and S2-2 of FIGURE 5, except that the image patches do not necessarily need to be identified as stereoscopic pairs (although they may be if desired).

[124] In step S201, a feature vector is derived from plural local image descriptors of the image patch. The feature vector may be derived using the methodology described above with reference to step S3 of FIGURE 3. The feature vector may take any of the forms discussed above.

[125] In step S202, the feature vector is used to select image editing instructions from reference data 102. The reference data 102 comprising image editing instructions for a range of possible values of the feature vector (representing for example different gaze directions and/or eye morphologies in the case where the target feature comprises an eye region).

[126] In step S203, the selected image editing instructions are applied to the image patch to adjust the image of the head region (e.g. to correct a gaze direction).

[127] In an embodiment, the image editing instructions are provided in a compressed representation, comprising for example one or more of the following: a principle component analysis representation; a wavelet representation; Fourier and/or discrete cosine transform components; cluster centres. The use of a compressed representation reduces data storage and bandwidth requirements during use of the image editing instructions to perform adjustment of an image of a head region. Alternatively or additionally, the reference data containing the image editing instructions may be generated using any of the embodiments disclosed herein. The reference data may comprise the second reference data discussed above for example.

[128] **FIGURE 12** schematically depicts data flow in a detailed example of a method of adjusting an image of a head region using reference data generated according to the detailed example of FIGURE 9. Input data ID is provided from a sensor system SS (e.g. comprising one or more cameras). The input data ID is input to the second selection instructions LA2 to select image editing instructions appropriate to the input data ID from the second image editing

instructions ED2. The selected image editing instructions, which in this example are provided in a compressed representation (e.g. principle component analysis components or wavelet components) from the compressed second image editing instructions ED2, are then used by the second image editing algorithm EA2, in combination with the auxiliary data AuxD providing the basis set for the compressed representation, to provide output data OD. The output data OD comprises an adjusted image of the head region and is displayed via a display DS.

[129] As described above, the method of adjusting an image of a head region may be implemented in an image processor 30 provided in various different devices. By way of non-limitative example, there will now be described a particular implementation in a telecommunications system which is shown in **FIGURE 13** and arranged as follows.

[130] In this implementation, the source device 10 and the destination device 10 communicate over such a telecommunications network 50. For communication over the telecommunications network 50, the source device 10 includes a telecommunications interface 17 and the destination device 20 includes a telecommunications interface 27.

[131] In this implementation, the image processor 30 is provided in the source device 10 and is provided with an image of a head region directly from a camera system 12 (in this example, a stereoscopic pair of images). The telecommunications interface 17 is arranged to transmit the adjusted images 38 over the telecommunications network 50 to the destination device 20 for display thereon.

[132] The destination device 20 includes an image display module 28 that controls the display 26. The adjusted images 38 are received in the destination device 20 by the telecommunications interface 27 and supplied to the image display module 28 which causes them to be displayed on the display 26.

[133] The following elements of the destination device 20 are optionally included in the case that the method corrects gaze for a destination observer 24 in an observer location other than a normal viewing position perpendicular to the center of the display location. In this case, the destination device 20 includes a camera system 23 and an observer location module 29. The camera system 23 captures an image of the destination observer 24. The observer location module 29 derives the location data 40. The observer location module 29 includes a head tracking module that uses the output of the camera system 23 to detect the location of the destination observer 24. The observer location module 29. Where the relative observer location

also takes into account the location of the image displayed on the display 21, the observer location module 29 obtains the location of the image displayed on the display 21 from the image display module 28. The telecommunications interface 17 is arranged to transmit the location data 40 over the telecommunications network 50 to the source device 10 for use thereby.

[134] Although the above description refers to a method applied to images supplied from a source device 10 to a destination device 20, the method may equally be applied to images supplied from in the opposite direction from the destination device 20 to the source device 10, in which case the destination device 20 effectively becomes the “source device” and the source device 10 effectively becomes the “destination device”. Where images are supplied bi-directionally, the labels “source” and “destination” may be applied to both devices, depending on the direction of communication being considered.

[135] While various embodiments in accordance with the principles disclosed herein have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of this disclosure should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with any claims and their equivalents issuing from this disclosure. Furthermore, the above advantages and features are provided in described embodiments, but shall not limit the application of such issued claims to processes and structures accomplishing any or all of the above advantages.

[136] Additionally, the section headings herein are provided for consistency with the suggestions under 37 CFR 1.77 or otherwise to provide organizational cues. These headings shall not limit or characterize the embodiment(s) set out in any claims that may issue from this disclosure. Specifically and by way of example, although the headings refer to a "Technical Field," the claims should not be limited by the language chosen under this heading to describe the so-called field. Further, a description of a technology in the "Background" is not to be construed as an admission that certain technology is prior art to any embodiment(s) in this disclosure. Neither is the "Summary" to be considered as a characterization of the embodiment(s) set forth in issued claims. Furthermore, any reference in this disclosure to "invention" in the singular should not be used to argue that there is only a single point of novelty in this disclosure. Multiple embodiments may be set forth according to the limitations of the multiple claims issuing from this disclosure, and such claims accordingly define the embodiment(s), and their equivalents, that are protected thereby. In all instances, the scope of such claims shall be

considered on their own merits in light of this disclosure, but should not be constrained by the headings set forth herein.

Claims:

1. A method of generating reference data for adjusting an image of a head region, the method comprising:

receiving training data comprising:

a set of input image patches, each input image patch comprising a target feature of an image of a head region prior to adjustment of the image of the head region, wherein the target feature is the same for each input image patch; and

a set of output image patches in one-to-one correspondence with the input image patches, each output image patch comprising the target feature of the image of the head region after adjustment of the image of the head region;

using a first machine learning algorithm to generate first reference data using the training data, the first reference data comprising image editing instructions for adjusting the image of the head region for a range of possible images of the head region; and

using a second machine learning algorithm to generate second reference data using the same training data as the first machine learning algorithm and the first reference data generated by the first machine learning algorithm, the second reference data comprising image editing instructions for adjusting the image of the head region for a range of possible images of the head region.

2. The method of claim 1, wherein:

the first reference data comprise first image editing instructions for a range of possible configurations of the target feature and first selection instructions for selecting image editing instructions for a particular input image patch from the first image editing instructions based on the configuration of the target feature of the input image patch; and

the second reference data comprise second image editing instructions for a range of possible configurations of the target feature and second selection instructions for selecting image editing instructions for a particular input image patch from the second image editing instructions based on the configuration of the target feature of the input image patch.

3. The method of claim 2, wherein the configuration of the target feature of each input image patch is represented by a feature vector derived from plural local image descriptors of the input image patch, and the first and second selection instructions define how the feature vector is used to select image editing instructions for the input image patch.
4. The method of claim 2 or 3, wherein the image editing instructions comprise a displacement vector field defining how the input image patch is to be transformed.
5. The method of claim 2 or 3, wherein the image editing instructions comprise a filter field, a brightness adjustment field, or a texture blending field.
6. The method of any of claims 2-5, wherein:
 - a first image editing algorithm is used by the first machine learning algorithm to define how the first image editing instructions are to be applied to an input image patch to derive an output image patch; and
 - a second image editing algorithm is used by the second machine learning algorithm to define how the second image editing instructions are to be applied to an input image patch to derive an output image patch.
7. The method of claim 6, wherein:
 - the second image editing instructions are principle component analysis components of a principle component analysis of the first image editing instructions; and
 - the second image editing algorithm is configured to transform the second image editing instructions into the first image editing instructions by inverse principle component analysis transform.
8. The method of claim 6, wherein:
 - the second image editing instructions are wavelet components of the first image editing instructions; and
 - the second image editing algorithm is configured to transform the second image editing instructions into the first image editing instructions by inverse wavelet transform.

9. The method of any of claims 2-8, wherein the first selection instructions for the first reference data are able to select between a larger number of alternative image editing instructions than the second selection instructions for the second reference data.
10. The method of any preceding claim, wherein the first machine learning algorithm is of a different machine learning algorithm type than the second machine learning algorithm.
11. The method of any preceding claim, wherein the first machine learning algorithm comprises one or more of the following: a neural network; a support vector machine; a generative adversarial network, GAN.
12. The method of any preceding claim, wherein the second machine learning algorithm comprises one or more of the following: a regression forest; regression ferns, cluster centres, a lookup table, separable filter banks.
13. The method of any of claims 1-10, wherein the first machine learning algorithm comprises a first neural network and the second machine learning algorithm comprises a second neural network, wherein the second neural network comprises fewer layers and/or smaller convolution fields than the first neural network.
14. The method of any preceding claim, wherein the target feature comprises one or more of the following: an eye region comprising at least part of an eye, a nose region comprising at least part of a nose, a mouth region comprising at least part of a mouth, a chin region comprising at least part of a chin, a neck region comprising at least part of a neck, and a hair region comprising hair.
15. The method of any of claims 1-13, wherein:
the target feature comprises an eye region comprising at least part of an eye and the adjustment of the image of the head region comprises adjusting a gaze direction;

the target feature comprises a nose region comprising at least part of a nose and the adjustment of the image of the head region comprises adjusting a shape and/or texture of the nose;

the target feature comprises a chin region comprising at least part of a chin and the adjustment of the image of the head region comprises adjusting a shape and/or texture of the chin;

the target feature comprises a neck region comprising at least part of a neck and the adjustment of the image of the head region comprises adjusting a shape and/or texture of the neck; and/or

the target feature comprises a hair region comprising hair and the adjustment of the image of the head region comprises adjusting a color of the hair.

16. The method of any preceding claim, wherein the second image editing instructions in the second reference data are provided in a compressed representation.

17. The method of claim 16, wherein the compressed representation comprises one or more of the following: a principle component analysis representation; a wavelet representation; Fourier and/or discrete cosine transform components; cluster centres.

18. A method of adjusting an image of a head region, the method comprising:
identifying an image patch in the image of the head region, the image patch comprising a target feature of the image of the head region;
deriving a feature vector from plural local image descriptors of the image patch;
using the feature vector to select image editing instructions from reference data, the reference data comprising image editing instructions for a range of possible values of the feature vector; and
applying the selected image editing instructions to the image patch to adjust the image of the head region, wherein:
the reference data comprises the second reference data generated by the method of any of claims 1-17.

19. A method of adjusting an image of a head region, the method comprising:
 - identifying an image patch in the image of the head region, the image patch comprising a target feature of the image of the head region;
 - deriving a feature vector from plural local image descriptors of the image patch;
 - using the feature vector to select image editing instructions from reference data, the reference data comprising image editing instructions for a range of possible values of the feature vector; and
 - applying the selected image editing instructions to the image patch to adjust the image of the head region, wherein:
 - the image editing instructions in the reference data are provided in a compressed representation.
20. The method of claim 19, wherein the compressed representation comprises one or more of the following: a principle component analysis representation; a wavelet representation; Fourier and/or discrete cosine transform components; cluster centres.
21. A computer program capable of execution by a processor and arranged on execution to cause the processor to perform a method according to any of the preceding claims.
22. A computer readable storage medium storing a computer program according to claim 21.
23. A device for generating reference data for adjusting an image of a head region, the device comprising a data processing unit arranged to:
 - receive training data comprising:
 - a set of input image patches, each input image patch comprising information about a target feature of an image of the head region prior to adjustment of the image of the head region, wherein the target feature is the same for each input image patch; and
 - a set of output image patches in one-to-one correspondence with the input image patches, each output image patch comprising the target portion of the image of the head region after adjustment of the image of the head region;

use a first machine learning algorithm to generate first reference data using the training data; and

use a second machine learning algorithm to generate second reference data using the same training data as the first machine learning algorithm and the first reference data output by the first machine learning algorithm.

24. A device for adjusting an image of a head region, the device comprising an image processor arranged to process the image of the head region by:

identifying an image patch in the image of the head region, the image patch comprising information about a target feature of the image of the head region;

deriving a feature vector from plural local image descriptors of the image patch;

using the feature vector to select image editing instructions from reference data, the reference data comprising image editing instructions for a range of possible values of the feature vector; and

applying the selected image editing instructions to the image patch to adjust the image of the head region, wherein:

the image editing instructions in the reference data are provided in a compressed representation.

25. The device of claim 24, further comprising a telecommunications interface arranged to transmit the adjusted image over a telecommunications network to a destination device for display thereon.

Abstract

Methods and devices for generating reference data for adjusting an image of a head region, and methods and devices for adjusting the image of a head region are disclosed. In one arrangement, training data are received. A first machine learning algorithm generates first reference data using the training data. A second machine learning algorithm generates second reference data using the same training data and the first reference data generated by the first machine learning algorithm.

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First Named Inventor/Applicant Name:		Eric Sommerlade		
Filer:		Penny Lea Lowry/Stefan Bump		
Attorney Docket Number:		409000A		
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Filing Fees for Provisional				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
PROVISIONAL APPLICATION FILING FEE	2005	1	130	130
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
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Total in USD (\$)				130

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Application Number:	62543587
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First Named Inventor/Applicant Name:	Eric Sommerlade
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RAM confirmation Number	081117INTEFSW15280600
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	WebADS.pdf	114937	no	7
			e3d188152fa2a5e5f27463cebd8ad071e3156853		
Warnings:					
Information:					
2	Provisional Cover Sheet (SB16)	409000A_ProvisionalSB.pdf	1477146	no	3
			ac68da89a090c8c96badb92700a011ead95b62e2		
Warnings:					
Information:					
3		409000A_PRV_Application.pdf	547583	yes	41
			8ffac0fd9e1da991ecee52dce679027811375569		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Drawings-only black and white line drawings		32	41	
	Specification		1	31	
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	29808	no	2
			550917399b99959f8ea43d41da6e80779aa53676		
Warnings:					
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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.