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13/491,033 7 June 2012 (07.06.2012) US
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(81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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[Continued on next page]

(54) **Title:** METHOD AND APPARATUS FOR CALIBRATING AN IMAGING DEVICE

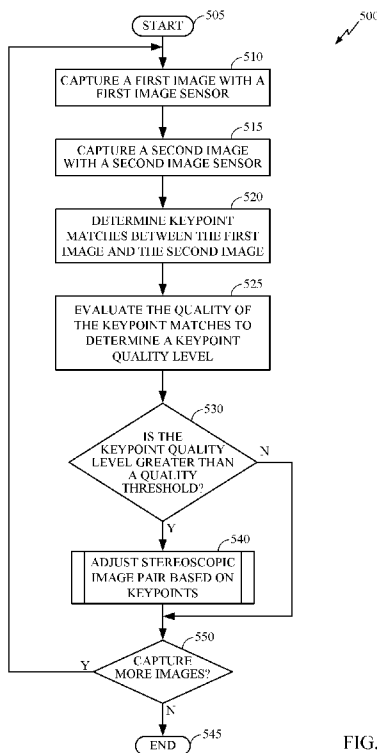


FIG. 5

(57) **Abstract:** Described are methods and apparatus for adjusting images of a stereoscopic image pair based on keypoint matches. The quality of the keypoint matches is first evaluated to determine whether the quality exceeds a keypoint quality threshold. If the quality level of the keypoint matches exceeds the threshold, the vertical disparity between the images of the stereoscopic image pair can be evaluated based on vertical disparity vectors between the keypoint matches. If the vertical disparity is below a threshold, no adjustment of the stereoscopic image pair may be performed. If the vertical disparity is above the threshold, an affine correction may compensate for pitch, roll, and scale differences between the images. A projective correction may compensate for yaw differences. The vertical disparity between the two images is then evaluated after the corrections to determine if additional adjustment should be performed.

WO 2013/009416 A3



TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

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INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T7/00 H04N13/02
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
G06T H04N
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/081642 A1 (THOMSON LICENSING [FR]; ZHANG TAO [US]; TIAN DONG [US]) 7 July 2011 (2011-07-07)	1,17,23, 28
Y	page 10, line 5 - page 14, line 4; figure 3 ----- -/--	2-16, 18-22, 24-27

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

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 21 December 2012	Date of mailing of the international search report 07/01/2013
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Tillier, Christophe
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/041514

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Fabrice Boutarel ET AL: "epipolar rectification for autostereoscopic camera setup", the 8th france-japan and 6th europe-asia congress on mechatronics, 24 November 2010 (2010-11-24), XP55037458, Retrieved from the Internet: URL: http://igm.univ-mlv.fr/~vnozick/publications/boutarel_EAM_2010/boutarel_EAM_2010.pdf [retrieved on 2012-09-06] the whole document	2-9,24
Y	Yun-Suk Kang ET AL: "stereo image rectification for simple panoramic image generation", International Conference on Embedded Systems and Intelligent Technology (ICESIT2009), 13 February 2009 (2009-02-13), XP55037462, Retrieved from the Internet: URL: http://vclab.gist.ac.kr/papers/03/2009/2009_3_YSKANG_Stereo_Image_Rectification.pdf [retrieved on 2012-09-06] the whole document	2-9,24
Y	EP 1 906 140 A2 (TOPCON CORP [JP]) 2 April 2008 (2008-04-02) paragraphs [0057], [0080]; figure 13	10,13, 21,27
Y	US 2010/164950 A1 (ZHAO WENYI [US] ET AL) 1 July 2010 (2010-07-01) the whole document	11,22
Y	"Scale-invariant feature invariant", 7 June 2011 (2011-06-07), XP055048379, Retrieved from the Internet: URL: http://en.wikipedia.org/w/index.php?title=Scale-invariant_feature_transform&oldid=433004794&printable=yes [retrieved on 2012-12-19] section "feature matching and indexing"; section "outlier detection"	12,14, 16, 18-20,26
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/041514

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>András Bódis-Szomorú ET AL: "calibration and sensitivity analysis of a stereo vision-based driver assistance system", stereo vision, 30 November 2008 (2008-11-30), XP055048492, ISBN: 978-9-53-761922-0 Retrieved from the Internet: URL:http://cdn.intechopen.com/pdfs/5777/In_Tech-Calibration_and_sensitivity_analysis_of_a_stereo_vision_based_driver_assistance_system.pdf [retrieved on 2012-12-20] section 5</p> <p style="text-align: center;">-----</p>	15,25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/041514

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 2-9, 24(completely); 1, 17, 23, 28(partially)

a method (apparatus, device and computer readable medium) of calibrating a stereoscopic imaging device and rectifying the stereoscopic images

2. claims: 10, 11, 21, 22(completely); 1, 17, 23, 28(partially)

a method (apparatus, device and computer readable medium) of calibrating a stereoscopic imaging device in response to some external conditions

3. claims: 12-16, 18-20, 25-27(completely); 1, 17, 23, 28(partially)

a method (apparatus, device and computer readable medium) of calibrating a stereoscopic imaging device with different constraints concerning the quality of matching feature points

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/041514

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011081642 A1	07-07-2011	US 2012249751 A1 WO 2011081642 A1	04-10-2012 07-07-2011

EP 1906140 A2	02-04-2008	EP 1906140 A2 JP 4800163 B2 JP 2008089314 A US 2008095402 A1	02-04-2008 26-10-2011 17-04-2008 24-04-2008

US 2010164950 A1	01-07-2010	US 2010164950 A1 WO 2010078018 A2	01-07-2010 08-07-2010
