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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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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.

(54) Title: SURFACE RECONSTRUCTION FOR ENVIRONMENTS WITH MOVING OBJECTS

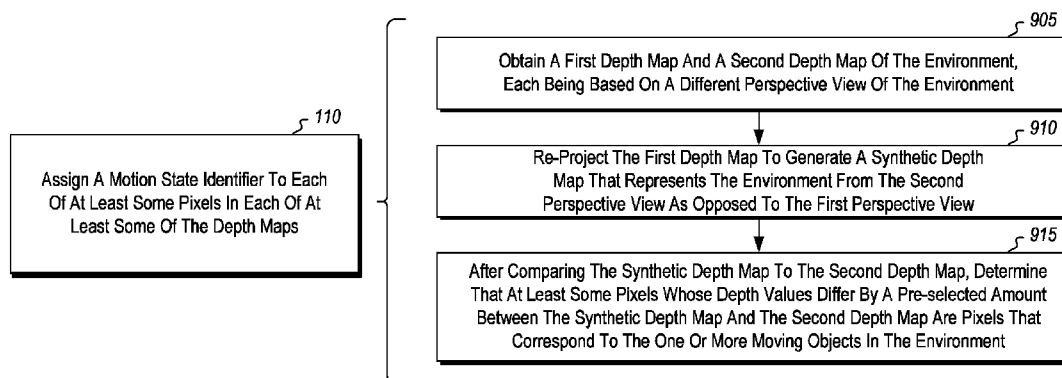


Figure 9

(57) Abstract: Optimizations are provided for reconstructing geometric surfaces for an environment that includes moving objects. Multiple depth maps for the environment are created, where some of the depth maps correspond to different perspectives of the environment. A motion state identifier is assigned to at least some pixels in at least some of the depth maps corresponding to moving objects in the environment. A composite 3D mesh is built using at least some of the multiple depth maps, by incorporating pixel information from the depth maps, while omitting pixel information identified by the motion state identifiers as being associated with moving objects.



(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, 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, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:

28 November 2019 (28.11.2019)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/027113

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.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/027113

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T17/20 G06T19/20
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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SHUHAN SHEN: "Depth-map merging for Multi-View Stereo with high resolution images", PATTERN RECOGNITION (ICPR), 2012 21ST INTERNATIONAL CONFERENCE ON, IEEE, 11 November 2012 (2012-11-11), pages 788-791, XP032329445, ISBN: 978-1-4673-2216-4	1-4,7,8, 10,11, 13,14
Y	Abstractr, Section 1, section 2 and subsections, in particular 2.3 ----- -/--	6,9,15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

17 October 2019

Date of mailing of the international search report

25/10/2019

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/027113

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Ioan Andrei Barsan: "Simultaneous Localization and Mapping in Dynamic Scenes", 1 January 2017 (2017-01-01), XP055631175, DOI: 10.3929/ethz-b-000202829 Retrieved from the Internet: URL:https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/202829/Bar san_Ioan.pdf?sequence=1&isAllowed=y [retrieved on 2019-10-15] Abstract, figure 4.4, sections 4.1,4.2,4.3 and subsections -----	6,9,15
X	SIFAN YANG ET AL: "Robust RGB-D SLAM in dynamic environment using faster R-CNN", 3RD IEEE INTERNATIONAL CONFERENCE ON COMPUTER AND COMMUNICATIONS (ICCC), 1 December 2017 (2017-12-01), pages 2398-2402, XP055630958, DOI: 10.1109/CompComm.2017.8322965 ISBN: 978-1-5090-6352-9 -----	12
A	Abstract, SectionsI, II., II.A, II.B. -----	5,8
A	ZHONG FANGWEI ET AL: "Detect-SLAM: Making Object Detection and SLAM Mutually Beneficial", 2018 IEEE WINTER CONFERENCE ON APPLICATIONS OF COMPUTER VISION (WACV), IEEE, 12 March 2018 (2018-03-12), pages 1001-1010, XP033337720, DOI: 10.1109/WACV.2018.00115 [retrieved on 2018-05-03] Abstract, Sections 1,3 and subsections, figure 1 -----	5,8,12

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

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

1. claims: 1-4, 7, 10, 11, 13, 14

Compositing depth maps with comparison of re-projection onto alternative perspective for detection of pixels corresponding to static and dynamic objects

2. claims: 5, 8, 12

Compositing depth maps with machine learning for detection of pixels corresponding to static and dynamic objects

3. claims: 6, 9, 15

Compositing depth maps with categorizing and segmenting for detection of pixels corresponding to static and dynamic objects
