

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

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PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing (day/month/year)	26/08/2020
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Applicant's or agent's file reference SP100880WO	FOR FURTHER ACTION See paragraph 2 below
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International application No. PCT/SG2020/050158	International filing date (day/month/year) 24/03/2020	Priority date (day/month/year) 26/03/2019
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International Patent Classification (IPC)
G06T 7/33 (2017.01) G06K 9/62 (2006.01) G06K 9/46 (2006.01) G06F 16/532 (2019.01)

Applicant
AGENCY FOR SCIENCE, TECHNOLOGY AND RESEARCH

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

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

2. FURTHER ACTION

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

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

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

<p>Name and mailing address of the ISA/SG</p> <p style="text-align: center;">Intellectual Property Office of Singapore</p> <p>IPOS <small>INTELLECTUAL PROPERTY OFFICE OF SINGAPORE</small></p> <p>1 Paya Lebar Link, #11-03 PLQ 1, Paya Lebar Quarter Singapore 408533</p> <p>Email: pct@ipos.gov.sg</p>	<p>Date of completion of this opinion</p> <p style="text-align: center;">24/08/2020</p> <p style="text-align: center;">(day/month/year)</p>	<p>Authorized officer</p> <p style="text-align: center;">Nae Win <u>Aung</u> (Mr)</p> <p>IPOS Customer Service Tel. No.: (+65) 6339 8616</p>
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WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/SG2020/050158

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:
 - the international application in the language in which it was filed.
 - a translation of the international application into _____ which is the language of a translation furnished for the purpose of international search (Rules 12.3(a) and 23.1 (b)).
2. This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(b)).
3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
 - a. forming part of the international application as filed:
 - in the form of an Annex C/ST.25 text file.
 - on paper or in the form of an image file.
 - b. furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
 - c. furnished subsequent to the international filing date for the purposes of international search only:
 - in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
 - on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).
4. In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.

PCT/SG2020/050158

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

1. Statement

Novelty (N)	Claims	<u>4-12, 14-16 AND 18</u>	YES
	Claims	<u>1-3, 13, 17, 19 AND 20</u>	NO
Inventive step (IS)	Claims	<u>NONE</u>	YES
	Claims	<u>1-20</u>	NO
Industrial applicability (IA)	Claims	<u>1-20</u>	YES
	Claims	<u>NONE</u>	NO

2. Citations and explanations:

The following citations are referred to in this written opinion. Full bibliographic details are provided in the International Search Report:

D1 – US 2012/0201469 A1

D2 – US 2018/0089832 A1

D3 – YUAN M. ET AL., 2018

D4 – CN 104794703 A

(a machine translation was used for the purpose of establishing the written opinion)

D5 – CN 108986168 A

(a machine translation was used for the purpose of establishing the written opinion)

D3 discloses outlier detection using hierarchical spatial verification for visual place recognition.

D4 discloses a real-time stereo matching system and method based on a ZNCC algorithm.

D5 discloses a robot loop detection method and device based on deep metric learning combined with a bag-of-words tree model.

D3-D5 are considered to be background art and thus they are not further discussed in this written opinion.

1. Novelty

Claims 1-3, 13, 17, 19 and 20 are not novel and therefore do not comply with PCT Article 33(2).

Claims 1, 13, 17, 19 and 20

Document **D1** discloses, using the language of claim 1 (references in parenthesis refer to **D1**):

A method of determining which of a plurality of reference images has lighting conditions which most closely match those of a query image (**Paragraphs [0008], [0009], [0070]**: the tracking method uses recursive information from the preceding images and information from one or more key images (i.e. a plurality of reference images) corresponding to the tracked object (i.e. a query image); several key images can be used to represent an object from several viewpoints (i.e. the key images would have lighting conditions under several viewpoints); **Figures 3a, 3b**), the method comprising, for each reference image:

- determining a set of matches between the reference image and the query image (**Paragraphs [0072], [0073]**: points of interest of a current image 305 and points of interest of a preceding image and/or points of interest of a key image; references 305, 315, 325 and steps 300, 310, 320 in **Figures 3a, 3b**),
- wherein a match comprises a first feature in the query image and a second feature in the reference image (**Paragraphs [0073], [0074]**: the image portions situated around the points of interest detected are then compared with those retrieved around the points of interest of the preceding image 315; the image portions around the active points of interest of the key image are re-projected according to the pose estimated on the basis of the preceding image and then compared to those associated with the points of interest of the current image that do not matched with points of interest of the preceding image;

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

references 305, 315, 325 and steps 310, 320 in **Figures 3a, 3b**),

- wherein the first and second features are both projections of the same point in three dimensional space (**Paragraphs [0074], [0075]**: the pose of the object is then estimated using the correspondences established between the points of interest of the current image with the points of interest of the preceding image and the key image; the correlation errors are preferably suppressed by using the estimated pose of the object by comparing the positions of the points detected and matched in the current image with the theoretical positions obtained by re-projecting the corresponding 3D coordinates of the key image with a predetermined threshold; references 305, 315, 325 and step 330 in **Figures 3a, 3b**); and
- calculating a Zero-Normalized Cross Correlation for the determined set of matches (**Paragraphs [0073], [0074]**: this correlation may in particular be carried out using an operator for comparing the intensity of image portions of the ZNCC (acronym for Zero-mean Normal Cross Correlation) type; this correlation can in particular be carried out using an operator for comparing the intensity of image portions of the ZNCC type between the points re-projected on the current image and the adjacent points of the current image),
- wherein the reference image corresponding to the set of matches having the highest value of Zero-Normalized Cross Correlation is determined to be the reference image with lighting conditions which most closely match those of the query image (**Paragraphs [0070]-[0077], [0116]**: the pose of the object is then estimated (step 330) using the correspondences established between the points of interest of the current image with the points of interest of the preceding image and the key image; validation of the matches made using, for example, a ZNCC; **Figures 3a, 3b**).

Therefore, claim 1 is not novel in view of **D1**.

Claims 13, 17, 19 and 20 are directed to a method, a system, a device and a computer readable medium, comprising features that substantially correspond to those of claim 1. The same objections to claim 1 apply, *mutatis mutandis*, to these claims and thus claims 13, 17, 19 and 20 are also not novel in light of **D1**.

Claims 1, 13, 17, 19 and 20 are not novel and therefore do not comply with PCT Article 33(2).

Claims 2 and 3

Claims 2 and 3 are not novel as the features added by these dependent claims are also disclosed in **D1: Paragraph [0073], [0074]**: steps 310, 320 in **Figure 3a**.

Claims 4-12, 14-16 and 18 are novel as the additional features defined in these claims are not disclosed by any of available cited prior art documents and therefore comply with PCT Article 33(2).

In summary, claims 1-3, 13, 17, 19 and 20 are not novel in view of **D1**, whereas claims 4-12, 14-16 and 18 are novel.

2. Inventive step

Claims 1-20 are not inventive and therefore do not comply with PCT Article 33(3).

Given the above novelty objection, claims 1-3, 13, 17, 19 and 20 do not involve an inventive step in light of **D1** and therefore do not comply with PCT Article 33(3).

Claims 12, 14-16 and 18

Document **D2** discloses, using the language of claim 12 with the missing features in the striking format (references in parenthesis refer to **D1**):

A method of selecting a visual vocabulary for use in visual place recognition (**Paragraphs [0031], [0041], [0042]**: a method 200 for place recognition using a vocabulary tree 500); **Figures 2, 5**), the method comprising:

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

- obtaining a first query image taken at a first exposure (**Paragraphs [0032], [0044]**: an input frame; references 202, 204 in **Figure 2**; reference 602 in **Figure 6**),
- wherein the first query image comprises an image obtained under the lighting conditions under which visual place recognition will be performed (**Paragraphs [0031], [0032], [0043], [0044]**: a landmark is a feature that can easily be observed across several frames and that can be easily distinguished from the surrounding environment; a landmark that can easily be observed across several frames is one that can be observed from different positions; place recognition should also compute the camera pose for the current frame (l) from the information that the set of key frames {Ki} contains; reference 602 in **Figure 6**);
- ~~determining which of a plurality of reference images has lighting conditions which most closely matches that of the first query image according to any of the preceding claims; and~~
- selecting a vocabulary corresponding to the reference image determined to have lighting conditions which most closely match those of the query image (**Paragraphs [0042]-[0044]**: with the vocabulary tree 500 and the detected features in the current frame (l), a Bag-of-Words (BoW) vector may be computed for current frame (l); the BoW vector can be seen as description of the image content. To retrieve the suitable candidates for place recognition, the candidates with a close BoW vector are retrieved; **Figure 5**; references 604A, 604B in **Figure 6**).

The difference between claim 12 and **D2** lies in that the claim further defines the feature of determining which of a plurality of reference images has lighting conditions which most closely matches that of the first query image according to any of the preceding claims. As **D2** in **Paragraphs [0042]-[0045]** and **Figure 6** further discloses matching the input image (reference 602) with a plurality of reference images having lighting conditions (references 604A, 604B, 606A-606D), the skilled person would be motivated to combine the teachings of **D1** as discussed in the objections to claim 1 and **D2** to enhance the matching performance. Therefore, claim 12 is not inventive in view of **D1** and **D2**.

Claim 14 is directed to a method, comprising features that substantially correspond to those of claim 12. The same objections to claim 12 apply, *mutatis mutandis*, to this claim and thus claim 14 is also not inventive in light of **D1** and **D2**.

Likewise, claims 15, 16 and 18 are directed to a method and a system, comprising features that substantially correspond to those of claims 1 and 12. The same objections to claims 1 and 12 apply, *mutatis mutandis*, to these claims and thus claims 15, 16 and 18 are also not inventive in light of **D1** and **D2**.

Claims 4-11

The additional features defined in claims 4-11 are directed to implementation details of spatial verification for visual place recognition and similarity transformation using Hough space and RANSAC algorithm which are considered to be well-known in the art (see for example, hierarchical spatial verification for visual place recognition in **D3**), and which would be obvious to the skilled person to integrate into the method and system of **D1** to further enhance the implementation of image analysis and recognition. Accordingly, these claims do not appear to contain any inventive technical features which, in combination with the features of any claim to which they refer, meet the requirements in respect of inventive step.

In summary, claims 1-20 lack an inventive step in light of **D1** and **D2**.

3. Industrial applicability

Claims 1-20 are industrially applicable and therefore comply with PCT Article 33(4).