**Claims**

1. A method of selecting a visual vocabulary for use in visual place recognition, the method comprising:

obtaining a query image taken at a first exposure, wherein the query image comprises an image obtained under lighting conditions under which visual place recognition will be performed;

determining which of a plurality of reference images has lighting conditions which most closely match those of the query image for each reference image by:

determining a set of matches between the reference image and the query image, wherein a match comprises a first feature in the query image and a second feature in the reference image, wherein the first and second features are both projections of the same point in three-dimensional space; and

calculating a Zero-Normalized Cross Correlation for the determined set of matches, 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; and

selecting a vocabulary corresponding to the reference image determined to have lighting conditions which most closely match those of the query image for use in visual place recognition.

2. The method of claim 1, wherein determining the set of matches between the reference image and the query image comprises:

determining a plurality of match candidates between the reference image and the query image; and

spatially verifying each match candidate.

3. The method of claim 2, wherein spatially verifying each match candidate comprises determining an individual similarity transform between a position of the first feature in the query image and a position of the second feature in the reference image.

4. The method of claim 2, wherein spatially verifying each match candidate comprises, for each of the plurality of match candidates:

determining an individual similarity transformation between a position of the first feature of the match candidate in the query image and a position of the second feature of the match candidate in the reference image, and

mapping the determined individual similarity transformations into a Hough space;

partitioning the Hough space into a plurality of partitions;

determining a plurality of groups,

wherein a group is comprised of all of the match candidates with individual similarity transforms that fall into the same partition;

for each group: determining a local similarity transformation; and

verifying a match candidate by:

calculating an error generated by describing the relative positions of the first feature of the match candidate in the query image and the second feature of the match candidate in the reference image with one of the determined local similarity transformations, and

determining that the error is below an error threshold.

5. The method of claim 4, further comprising: determining a number of individual similarity transformations falling within a partition, and

wherein the number of individual similarity transforms falling within the partition exceeds a threshold.

6. The method of claim 5, further comprising:

determining a score for each of the plurality of partitions, wherein the score of a partition depends on the number of individual similarity transformations falling within the partition;

determining a given number of partitions with the highest scores;

determining a number of individual similarity transformations falling within each partition of the given number of partitions with the highest scores, and wherein

a group is comprised of all of the match candidates with individual similarity transforms that fall into the same partition of one of the given number of partitions with the highest scores, wherein the number of individual similarity transforms falling within the partition exceeds a threshold.

7. The method of any one of claims 4 to 6, wherein determining a local similarity transformation for each group comprises calculating a mean of all of the individual similarity transformations of the match candidates in each group.

8. The method of any one of claims 4 to 7, wherein calculating an error generated by describing the relative positions of the first feature of the match candidate in the query image and the second feature of the match candidate in the reference image with one of the determined local similarity transformations comprises calculating a two-way projection error.

9. The method of any one of claims 4 to 7, wherein determining that the error is below an error threshold comprises applying a Random sample consensus (RANSAC) algorithm and determining that the individual similarity transform of the match candidate is an inlier of one of the determined local similarity transformations.

10. The method of any one of claims 4 to 9, wherein the Hough space is 4 dimensional, with each dimension corresponding to one of: translation in a first direction, translation in a second direction, scale, and orientation, and wherein the dimension corresponding to orientation is partitioned into no more than two partitions.

11. The method of any one of claims 4 to 9, wherein the Hough space is 3 dimensional, with each dimension corresponding to one of: translation in a first direction, translation in a second direction and scale.

12. A method of selecting an exposure for obtaining images for use with a visual vocabulary in visual place recognition, the method comprising:

obtaining a plurality of query images, each query image being taken at a different exposure;

determining which of the plurality of query images has an exposure which most closely matches that of a reference image taken from a visual vocabulary by:

determining a set of matches between the reference image and the query image, wherein a match comprises a first feature appearing in the query image and a second feature appearing in the reference image, wherein the first and second features are both projections of the same point in three-dimensional space; and

calculating a Zero-Normalized Cross Correlation for the determined set of matches, wherein the query image with the highest value of the Zero-Mean Normalized Cross Correlation for the set of determined matches is determined to be the query image with an exposure which most closely matches that of the reference image; and

selecting the exposure corresponding to the query image determined to have an exposure which most closely matches that of the reference image for use with a visual vocabulary in visual place recognition.

13. A method of selecting an exposure and a visual vocabulary for use in visual place recognition, the method comprising;

obtaining a plurality of query images, each query image being taken at a different exposure;

for each query image, determining a Zero-Mean Normalized Cross Correlation between each of a plurality of reference images and the query image, wherein determining a Zero-Mean Normalized Cross Correlation between the query image and a reference image comprises:

determining a set of matches between the reference image and the query image, wherein a match comprises a first feature appearing in the query image and a second feature appearing in the reference image, wherein the first and second features are both projections of the same point in three-dimensional space; and

calculating a Zero-Mean Normalized Cross Correlation for the set of matches, and

determining which combination of a query image and reference image gives rise to the largest value of Zero-Mean Normalized Cross Correlation; and

selecting the exposure of the query image and the visual vocabulary of the reference image corresponding to that combination.

14. A method of verifying a plurality of match candidates between a first image and a second image, wherein a match candidate comprises a first feature appearing in the first image and a second feature appearing in the second image, wherein the first and second features are hypothesised to be projections of the same point in three-dimensional space, the method comprising:

for each of the plurality of match candidates, determining an individual similarity transformation between a position of the first feature in the first image and a position of the second feature in the second image;

grouping at least some of the plurality of match candidates into a plurality of groups according to their respective individual similarity transformations;

for each group, determining a local similarity transformation; and

verifying a match candidate by: calculating an error generated by describing the match candidate with one of the determined local similarity transformations; and

determining that the error is below an error threshold, wherein the first image and the second image are represented by a histogram of a set of features using a visual vocabulary, and wherein the first feature and the second feature of a match candidate are hypothesized to be the same by virtue of their corresponding to the same feature of the visual vocabulary, and wherein the visual vocabulary is chosen using the method of claim 1.

15. A system for determining lighting conditions, the system comprising:

an input for receiving a query image representative of a lighting condition to be determined;

a memory storing a plurality of reference images, the reference images being representative of different lighting conditions; and

a processor configured to perform the method of any of claims 1 to 11.

16. A system for performing visual place recognition, the system comprising:

an input for receiving a query image;

a memory storing a plurality of reference images; and

a processor configured to perform the method of claim 14**.**

17. A mobile robotic device comprising:

a camera; and

the system of claim 15.

18. A computer readable medium configured to cause a processor to perform the method of any one of claims 1 to 11.