COMP9517: Computer Vision
2020 T2 Lab 2 Specification
Maximum Marks Achievable: 2.5

This lab is **worth 2.5% of the total course marks**.

The lab files should be submitted online.
Instructions for submission will be posted closer to the deadline.
Deadline for submission is Week 4, Wednesday 24 June 2020, 23:59:59.

Objective: This lab revisits important concepts covered in the lectures of Week 3 and aims to make you familiar with implementing specific algorithms.

Materials: The sample image as well as template code to be used in the tasks of this lab is available in WebCMS3. You are required to use OpenCV 3+ with Python 3+. Jupyter notebook files are preferred for submitting your code.

Submission: The tasks are assessable **after the lab**. Submit your code and results in a zip file via WebCMS3 by the above deadline.

SIFT: Scale-Invariant Feature Transform
A well-known algorithm in computer vision to detect and describe local features in images is the scale-invariant feature transform (SIFT). Its applications include object recognition, mapping and navigation, image stitching, 3D modelling, object tracking, and others.

A SIFT feature of an image is a salient keypoint with an associated descriptor. SIFT computation is commonly divided into two steps: 1) detection and 2) description.

At the end of the detection step, for each keypoint the SIFT algorithm computes the:

- keypoint spatial coordinates (x, y),
- keypoint scale (in the scale space),
- keypoint dominant orientation.

The description step computes a distinctive 128-dimensional feature vector for each keypoint. SIFT is designed to be invariant to scale and rotation. Moreover, the algorithm offers decent robustness to noise, illumination gradients, and affine transformations.

SIFT in OpenCV

In OpenCV the SIFT algorithm is available only in the non-free module (OpenCV has both free and non-free modules). The algorithm has been patented by the creator but can be freely used for academic and research purposes. The non-free modules can be found in the opencv_contrib package. You will first need to install this package, as shown below, and then you can use the SIFT module.

Initialize and activate the virtual environment (optional):

```
$ python3 -m venv env
$ source venv/bin/activate
```

Install the correct version of OpenCV and the contrib module:

```
$ pip install opencv-python==3.4.2.17
$ pip install opencv-contrib-python==3.4.2.17
```

Task 1 (0.5 mark): Compute the SIFT features of the given image.

a) Extract SIFT features with default parameters and show the keypoints on the image.
b) To achieve better visualization of the keypoints, reduce the number of keypoints.
   Hint: Vary the parameter **contrastThreshold** or **nfeatures** so that the number of keypoints becomes about 10% of all default keypoints.

Submit the images obtained in a) and b) and mention the approach you used in b).

Task 2 (1 mark): Change the scale of the image and recompute the SIFT features.

a) Enlarge the given image by a scale percentage of 115.
b) Extract the SIFT features and show the keypoints on the scaled image using the same parameter setting as for Task 1 (for the reduced number of keypoints).
c) Inspect the keypoints visually: Are the keypoints of the scaled image roughly the same as those of the original image? What does this observation imply?
d) Match the SIFT descriptors of the keypoints of the scaled image with those of the original image using the nearest-neighbour distance ratio method. Show the keypoints of the 5 best-matching descriptors on both the original and the scaled image.
   Hint: Brute-force matching is available in OpenCV for feature matching.

Submit the images obtained in b) and d) and your answers to the questions in c).

Task 3 (1 mark): Rotate the image and recompute the SIFT features.

a) Rotate the given image clockwise by 60 degrees.
b) Extract the SIFT features and show the keypoints on the rotated image using the same parameter setting as for Task 1 (for the reduced number of keypoints).
c) Inspect the keypoints visually: Are the keypoints of the rotated image roughly the same as those of the original image? What does this observation imply?

d) Match the SIFT descriptors of the keypoints of the rotated image with those of the original image using the nearest-neighbour distance ratio method. Show the keypoints of the 5 best-matching descriptors on both the original and the rotated image.

Submit the images obtained in b) and d) and your answers to the questions in c).

Note: Refer to https://docs.opencv.org/3.4.3/da/df5/tutorial_py_sift_intro.html for an example of computing SIFT features and showing the keypoints on the image.

Reference: D. G. Lowe. Distinctive image features from scale-invariant keypoints. International Journal of Computer Vision, vol. 60, no. 2, pp. 91-110, November 2004. https://doi.org/10.1023/B:VISI.0000029664.99615.94

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