COMP 558: Assignment 4
Available: Thursday, November 23rd, 2017
Due Date: Thursday, December 7th, 2017 (before midnight) via myCourses.

Notes: I EXPECT EVERYONE TO SUBMIT ORIGINAL WORK FOR THIS ASSIGNMENT. This means that if you have consulted anyone or any sources (including source code or websites), you must disclose this explicitly. We will be checking your reports for this, so make sure you present ideas in your own words. Your submission should be in the form of an electronic report (PDF), with the answers to each question, and a well organized presentation and discussion of your results. This is a key part of this assignment. You will be given two datasets to work with, each of which contains 5 snapshots in a sequence of images. There is a rotation of the camera about its optical centre to generate each sequence (the amount of translation of the camera between frames is very small). In addition each dataset contains an image called "sample_result" which illustrates what your final output could look like, once your stitching algorithm is working. Finally we also provide some sample code "SIFT_feature.m", which can be used for illustration in question 1 and then, in modified form, in question 4. Submit documented Matlab code that you have written to generate your results as a separate file and in the text of the report explain the methods you have used, along with visualizations of results where appropriate.

Question 1: SIFT Features (10 marks)

The scale invariant feature transform (SIFT) was proposed by David Lowe and his students, based on properties of scale space. Refer to his 2004 IJCV paper (International Journal of Computer Vision, 2004, Volume 60, Issue 2, pp 91110) "Distinctive Image Features from Scale-Invariant Keypoints" and in no more than 3 paragraphs provide a brief discussion of what this representation entails, and how it is computed. Be sure to explain the mathematical under-pinnings, i.e., how is scale-invariance achieved? Using the code we have provided illustrate its performance on two consecutive images from one of the datasets.

Question 2: RANSAC (10 marks)

In computer vision random sample consensus (RANSAC) is an algorithm for estimating a model from a data set that contains outliers. Briefly, in no more than 2-3 paragraphs, explain how this algorithm works for a general model fitting problem.

Then, in no more than 2-3 paragraphs, explain how it could be used to estimate a general homography between two images that are approximately related by a homography. Here you should consider the problem of looking at a scene which contains planes from cameras at two different locations and orientations, i.e., the case discussed at the end of Mike Langer's lecture notes on homographies. You can assume that distinctive feature points are available in the first image (set 1) and in the second image (set 2), such as the SIFT features you illustrated in question 1.

Question 3: Feature Matching (10 marks)

We shall now build on the ideas above, using the first set of images we have provided, where you have a sequence of images created by an approximate rotation of a camera about its optical centre. First, using the code we have provided, create a selected number of SIFT features in two consecutive images. Then, for a successive image pair in the sequence, illustrate the process of matching features. Here you can use a naive notion of a match, such as that implemented in Matlab's built in *matchFeatures* function. Provide a few illustrations of matched features in your report between successive image pairs, and discuss any particular implementation details behind your approach along with the feature matching strategy you have used.

Question 4: Use of RANSAC to Stich Images (40 marks)

Now, building on your results so far, implement the ideas in the RANSAC example discussed in the lecture notes and slides, for estimating the best approximate homography between a successive image pair. Be careful here, because a number of steps are required (we shall elaborate on these in class). Once you have the homography between two successive images, apply the mapping technique from the first image to the second, to create an overlay. Apply the same stitching strategy iteratively (using your pair-wise estimated homographies) to ultimately create a panorama (one for each dataset). To give you an idea of what these panoramas might look like we have provided sample solutions for each sequence.

Question 5: Failure of Algorithm (10 marks)

Come up with a set of images for which the above algorithm fails, and demonstrate the failure. More importantly, discuss the circumstances under which image stitching algorithms which rely on pairwise homographies would fail.