ECE661: Homework 5

Fall 2016
Deadline : October 13, 2016 , 1:30 pm

Turn in typed solutions via Blackboard. Additional instructions given at [I]

1 Introduction

In this homework you will implement the image mosaicing technique to stitch several images together using homographies. Note that these images should contain considerable overlap for the technique to work. Image mosaicing is similar to creating a panoramic view of a scene from a camera using a sequence of images. You need to complete the following tasks for this homework.

2 Tasks

1. Collect a **minimum of 5** photos by standing in a fixed location and turning through some angle as you take each successive shot. Ensure that there is sufficient overlap between successive photos, otherwise you will not be able to establish good correspondences between images.

2. For each pair of adjacent images, do the following

   - Using any feature-matching algorithm establish interest point correspondences between successive images. You can use the Harris Corner detector that you developed for the previous homework, or SURF or SIFT from OpenCV or MATLAB. Although, note that SIFT and SURF will generally perform better than Harris.
   - Implement your own RANSAC algorithm to discard outliers from the estimated correspondences. You will need to set suitable values for the three RANSAC parameters -: δ , M and N, where δ is the threshold to select the inlier set, M is the minimum size of an acceptable inlier set and N controls the number of iterations. If you wish, you could try to use the 10 % rule described in the Lecture notes for deciding the value of δ. Refer the lecture notes for tips on setting M and N as well.
   - Using the linear-least squares method, calculate the homography between the pairs of images with the help of the selected inlier set of correspondences. (note - This involves finding the eigenvector that corresponds to the smallest eigenvalue in the SVD of a matrix.)
   - Implement the Dog-Leg method (refer Lecture notes) to refine your homography estimates.

3. Using the computed homographies, stitch the images together by chaining the homographies in order to project them into the coordinate frame of the center image.

4. Qualitatively compare the performance using Dog-Leg refinement and not using any refinement

2.1 Additional Task for Extra Credit

This task is for extra credit in which you refine the homographies using bundle adjustment technique. In bundle adjustment technique, you need to define an error function based on the summation of all the residuals obtained for all the feature matches across all the image pairs.

To begin let's assume that there are three images named i, j, and t. You have already established the interest point correspondences and obtained an initial estimate of the homographies i.e. H_{ij} and H_{jt}. Here, H_{ij} is the homography between image i and image j.

Assume that there is correspondence $u_i^k <--> u_j^l$. Here, u_i^k is the kth feature in image i. Then the residuals are given as $r_{ij}^k = u_i^k - p_{ij}^k$. Here, p_{ij}^k is defined as the projection from the image j to image i of the point corresponding to u_i^k based on the homography H_{ij}.

Then the global error function is given by: $e = \sum_{i=1}^{n} \sum_{j \epsilon I(i)} \sum_{k \epsilon F(i,j)} h(r_{ij}^k)$. Here, $I(i)$ is the set of all the images matching to the image i, $F(i,j)$ is the set of all the feature matches between the image i and image j, and h represents the L_2 norm.

Once you have defined the error function. You can use Levenberg-Marquardt to refine the homography estimate. You will find the the Levmar package [II] useful for this purpose. For more information on how to do bundle adjustment for image mosaicing, please refer to [III]. Note that for this task you can use any bundle adjustment sofware you can find online.

2.2 Notes

Draw lines to indicate the selected correspondences. **Do not** use the built-in Ransac and Dog-Leg functions. You can look at sample solutions from previous years.**Your final report must be your own**.

3 Submission

1. Turn in a typed pdf of your report via Blackboard.
2. Your pdf must include
    - A good description on your implementation of RANSAC alogirthm, the least squares method to estimate homographies and the Dog-Leg algorithm to refine them with relevant equations.
    - A description of the steps involved in your image mosaicing method, with relevant equations.
    - The extracted correspondences between sets of adjacent images.
    - The outliers and selected inliers for at least two pairs of images.
    - The final output mosaic.
    - The parameters that you chose for the experiments.
    - Your source code.

References

[I] `http://web.ics.purdue.edu/~sakbar/ECE661/`
[II] `http://users.ics.forth.gr/~lourakis/levmar/`
[III] Matthew Brown and David G. Lowe, "Automatic Panoramic Image Stitching using Invariant Features", IJCV, 2007