ECE661: Homework 2

Fall 2020

Due Date: Sept 10,2020

In this homework, you will estimate homographies between the given set of images and use the estimated homographies to transform images. You're free to choose your own programming language and library from the given list, however you can NOT use any built-in functions to compute homography matrices or for image warping.

Turn in typed solutions via BrightSpace. Additional instructions can be found at BrightSpace.

1 Programming Tasks

You will be calculating a homography between two images by manually recording the pixel coordinates of a set of corresponding points in the two images and using these coordinates to calculate the unknown elements of the homography.

All the necessary information to complete this task is divided in the following sections. Section 1.1 gives an overview of the problem definition. Section 1.2 has a list of recommended libraries and tools. The two programming tasks for this homework are defined in Sections 1.3 and 1.4. Section 1.5 has some additional tips to obtain more robust homography estimation. Finally, the homework submission instructions are given in Section 1.6.

1.1 Overview

The goal of this homework is to apply your conceptual understanding about homography estimation to transform one image onto another. For homography estimation, we need correspondence points between an image pair. For this homework, you will find the coordinates for the correspondence points using one or more of the recommended tools given in the following section. Then show your results for the tasks given in Sections 1.3 and 1.4.

1.2 Recommended Tools and Libraries

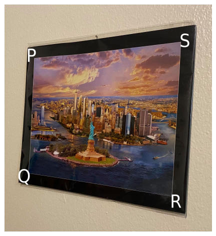
The following are some of the recommended options, you're free to choose the tools and libraries based on your own comfort level.

- **Programming languages:**
  - Python (Anaconda [4]) with scikit-image or OpenCV. It's highly recommended to learn how to manage environments [4] as opposed to installing libraries system-wide.
  - C/C++ with OpenCV, Eigen for linear algebra, etc. Some commonly used IDEs are Visual Studio, Eclipse, etc. More seasoned programmers typically use make or cmake [3] for cross-platform compilation.
- **Tools to obtain a pixel coordinates in an image:**
  - GUI-based tools: GIMP [1] for Linux users and IrfanView [2] or GIMP for Windows users.
  - Command-line tools: ImageMagick [5] has a nice collection of command-line image manipulation tools. Alternatively, if you don't want to install anything on your system, simply load an image with python and plot using Matplotlib, when you hover your mouse pointer over the plotted image you can see the point coordinates in the status bar.

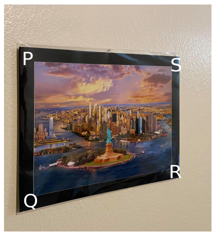
1.3 Task 1

You are given four images which are shown in Figs. 1a, 1b, 1c, and 1d. The first three images consist of a painting hanging on a wall, while the fourth image is a randomly picked image of kittens from the Internet. Complete the following tasks using these images.

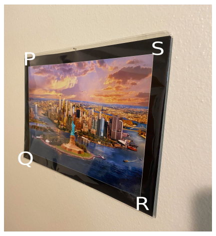
1. Pick a region of interest (ROI) covering the three kittens in Fig. 1d and project on the frame PQRS shown in Figs. 1a, 1b, and 1c. For this task, you need to find homographies between the following pairs of images: (1) images shown in Figs. 1d and 1a, (2) images shown in Figs. 1d and 1b, and (3) images shown in Figs. 1d and 1c.
2. Find homographies between images shown in Figs. 1a and 1b, and between images shown in Figs. 1b and 1c. Then apply the product of



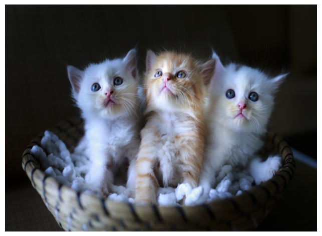
(a) View1 of the painting image



(b) View2 of the painting image



(c) View3 of the painting image



(d) Object image for mapping

Figure 1: Images for Task1. Note that both outer or inner corner points of the given painting images are acceptable solutions. Download the input images provided for the Task1 separately.

the two homographies to the image shown in Fig. 1a. The resulting image should look similar to the image shown in Fig. 1c.

You can use an image editor such as GIMP or IrfanView to determine the pixel coordinates of a point in an image.

1.4 Task 2

Repeat the steps of Task 1 using your own images. You can capture three images of a planar surface from three different viewpoints such as the ones shown in Figs. 1a, 1b, and 1c. For the fourth image you can obtain a picture of your choice (animal, celebrity, etc.) from the Internet or use a picture of your own.

1.5 Additional Notes

- To project your chosen ROI shown in Fig. 1d into the frame $PQRS$ you can draw a bounding box $P'Q'R'S'$ around in Fig. 1d and estimate the homography using the corresponding pairs of points. In this case PP', QQ', RR', and SS' are the corresponding pairs of points. However, using just four correspondences for computing a homography is likely to give you very poor results. When using a system of linear equations for calculating the unknowns, a general rule of thumb is that you need five times as many equations as the number of unknowns. For this homework, we just want you to experiment with increasing the number of equations though additional correspondences between the two images

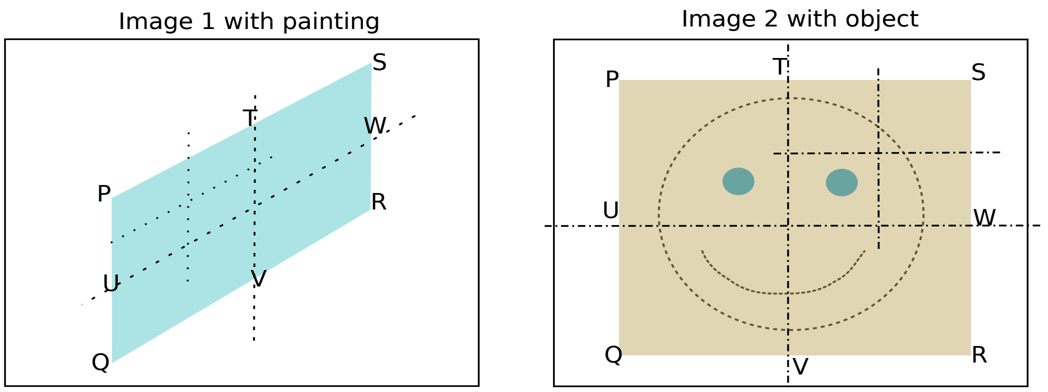


Figure 2: Increasing the number of correspondences between a pair of images. Note that the smaller bisectors are just symbolic. They show how to obtain larger number of correspondences with just four manually picked points.

of an image pair. For example, you can double the number of equations by using the perpendicular bisectors of the bounding boxes as shown below (see Fig. 2). Use such ploys to whatever extent you wish and see how that affects the quality of your homographies.

- For debugging your code efficiently, plot intermediate output at every important step and verify it visually. For example, after recording pixel coordinates manually, plot those points on your input images and verify visually if those points are correct.

1.6 Submission Instructions

Include a typed report explaining how did you solve the given programming tasks.

1. Turn in a zipped file with a typed pdf report with source code files. Include your input and output images in the report itself. Rename your .zip file as hw2_<First Name><Last Name>.zip and follow the same file naming convention for your pdf report too.
2. Your pdf must include a description of
   - The logic that you used to solve the given tasks.
   - The steps that you used to compute the homographies including equations.
   - Your own input images for Task 2 and output images for the two tasks.

- Your source code. Make sure that your source code files are adequately commented and cleaned up.

3. Indicate the points that you used on each image to obtain the homographies.

4. In order to avoid large file size of your submission, include JPEG images in your report for showing your results and your input images for Task2.

5. The sample solutions from previous years are for reference only, it's important not to get too biased by those solutions. You're free to format your report however you like as long as it addresses all the required components in the given programming tasks. There are many possible ways to format your report. For example, you're free to generate your pdf report using Jupyter notebook with inline explanation and results, and include your python code (.py files) separately. **Your code and final report must be your own work.**

References

[1] GNU Image Manipulation Program. URL `https://docs.gimp.org/2.10/en/`.

[2] IrfanView. URL `https://www.irfanview.com/`.

[3] CMake Tutorial. URL `https://cmake.org/cmake/help/latest/guide/tutorial/index.html`.

[4] Anaconda – Managing Environments. URL `https://docs.conda.io/projects/conda/en/latest/user-guide/getting-started.html`.

[5] ImageMagick – Command-line Tools. URL `https://imagemagick.org/script/command-line-tools.php`.