CSCI 55700
Image Processing and Computer Vision
Spring 2023
Project 1: Camera Calibration
Due Date: March 5, 2023, 11:59pm.

Introduction

This is your first graded programming project in CSCI 55700. The goal of the project is to get you started working with images and to implement a camera calibration method. You will have 2 weeks to implement, test, and write a report on the results for this project.

Project Description

In this project, you will implement camera calibration as described in your textbook and lectures. You will be given information about a calibration rig and a picture of the rig as part of the given data for this project (See Figure 1).

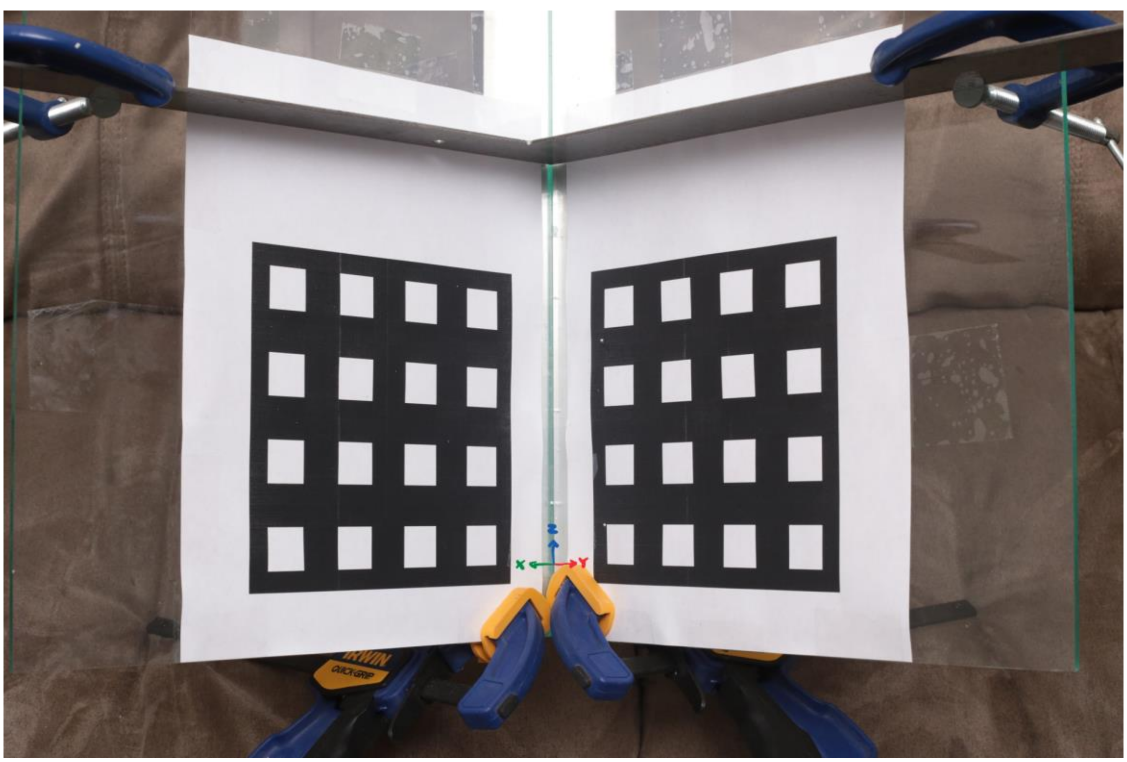

Figure 1: The calibration rig which you will use to do the camera calibration. The full image is uploaded as part of the project 1 data in the files section.

In order to calibrate the camera, you will need the 3D coordinates of the points on the grid in the calibration rig. These details are given in Figure 2. Figure 3 shows another picture that details the grid coordinates.

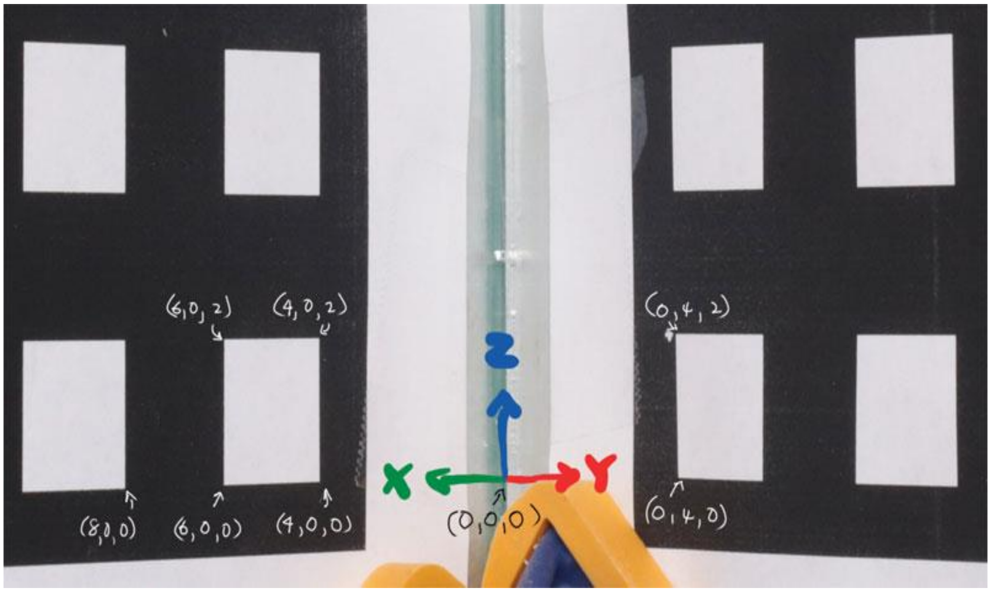

Figure 2: Details of the grid coordinates and measurements.

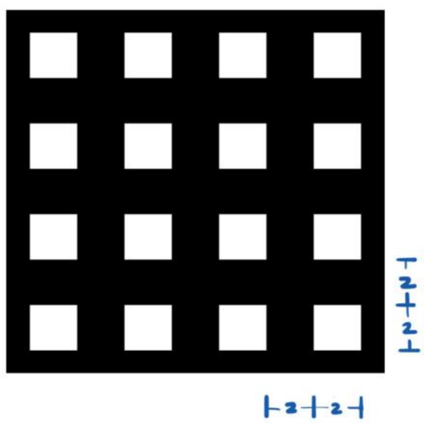

Figure 3: Details of the grid coordinates and measurements.

Your task is to:

1. Pick a sufficient number of data points from the rig image to estimate the camera parameters.

2. You will pick the image points of the calibration rig manually. How you do this is up to you, but don't try to automate it because we have not yet seen the methods to do so. You can try to write a GUI interface which will allow you to click on these points and have them saved in a file which you can then process. Or you can use an image processing program such as ImageJ or Photoshop or Gimp which will display the pixel

coordinates as you move the mouse cursor over the image (and thus the points of interest in the image) and then note these coordinates somewhere to be saved in a file.

3. Then do the numerical calculations to estimate the camera parameters: (a) intrinsic parameters, and (b) extrinsic parameters.

4. Do an error analysis. Using these estimated camera parameters, reproject the known 3D grid points from the calibration rig onto the image. Then analyze the errors between the original image coordinates you used to do the calibration and the reprojected points in the image. Compute statistics of these errors. Also look and see if there are certain trends in the errors.

For this project, you may ignore the nonlinear distortions due to the lens. Assume there is no distortion. Also assume that the skew $s = 0$.

You will have to do numerical computations for this project. Therefore, you may have to use some numerical/linear algebra libraries. Once you get the image and world coordinates, you may do all these calculations in Matlab if you so desire. Or write your own programs. Be careful, though. Writing robust numerical functions can be tricky. It is safer if you use something already implemented and debugged properly.

What to hand in

You will hand in a report and source code for this project. Put the source code as well as any supporting data into a single folder, then zip the folder. Upload this zipped file into Canvas as your submission. Upload the report as a separate document either as word or pdf file.

The report should contain the following:

1. A short introduction and a brief description of the theory and the algorithms you are implementing.

2. The results of running your implementation: the camera intrinsic and extrinsic parameters.

3. The results of your error analysis. Compute statistics about the errors in the locations of the projected image points and discuss any trends in the errors and also discuss where errors may be introduced in this process.

4. An analysis/interpretation of your results: A short discussion and any conclusions you may draw. Anything else you can think of. For example, you can repeat the estimation process for a few times (2-3 times) and see how the estimates vary by variations in the image pixel coordinates you pick. What does this mean?

Have Fun!