CSE462/562 – Augmented Reality (Fall 2019)

Homework #2

Handed out: 9:00am Tuesday October 22, 2019.

Due: 11:55pm Thursday November 7, 2019.

Problem 1 (40 pts): Given the following marker and its three images (HW2_P1.rar), you are asked to calculate the homography matrix such that:

$$\rho \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix},$$

where $S_i = [x_i \quad y_i]^T$ and $I_i = [u_i \quad v_i]^T$ are the coordinates of a corresponding point on the marker and camera images respectively.

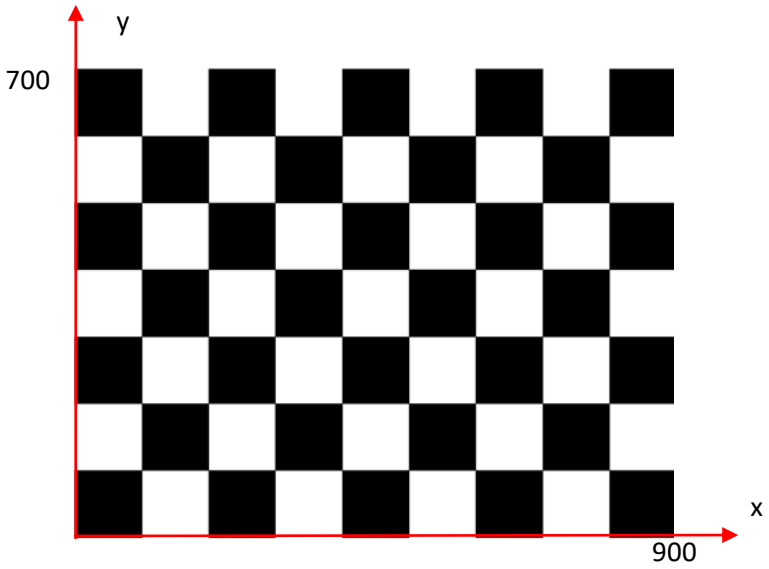
1.1. Write a C# function that given a set of point correspondences $S_i = [x_i \quad y_i]^T$ and $I_i = [u_i \quad v_i]^T$ calculates the corresponding homography matrix. You can assume that there are equal number of points for S_i and I_i and they are in correspondence. This function should use a non-linear optimization method to calculate the homography.

1.2. Write another C# function that does the same thing as 1.1. However, the list of points on the marker and the image are not guaranteed to match. This function will take another parameter as a matrix of numbers with entries $C_{i,j}$ indicating the degree of match between S_i and I_j.

1.3. Write another C# function that given a scene point $\begin{bmatrix} x_i \\ y_i \end{bmatrix}$ and a homography matrix, calculates the projection of the given point onto the target image.

1.4. Write another C# function that given an image point $\begin{bmatrix} u_i \\ v_i \end{bmatrix}$ and a homography matrix, calculates the projection of the given point onto the scene.

1.5. You are to find at least five points correspondences manually. Show the calculated matrices for each image using these point matches. Calculate the error for another 3 point matches you identify. Errors can be calculated as the Euclidean distance between the image of the point and the projected point. Use the following coordinate system for the scene.



Input images: Homework_2_img1.jpg, Homework_2_img2.jpg, Homework_2_img3.jpg

1.6. Find the projection of the following scene points onto the image.

$$S_1 = \begin{bmatrix} 7.5 \\ 5.5 \end{bmatrix}, S_2 = \begin{bmatrix} 6.3 \\ 3.3 \end{bmatrix} \text{ and } S_3 = \begin{bmatrix} 0.1 \\ 0.1 \end{bmatrix}.$$

1.7. Find the projection of the following image points onto the scene.

$$I_1 = \begin{bmatrix} 500 \\ 400 \end{bmatrix}, I_2 = \begin{bmatrix} 86 \\ 167 \end{bmatrix} \text{ and } I_3 = \begin{bmatrix} 10 \\ 10 \end{bmatrix}.$$

Problem 2 (60 pts): Given a scene in 19 images (HW2_P2.rar) (an example is shown below), place a teapot (with a square bounding box with 15cm length) on the white object at the end of the cables. The center of the bottom of the teapot should be at the center of the red dot). As a reference you have the USB connectors which can be used to get the right dimensions of the scene. You should do this placement on all the images given in the set. The placement geometry calculation can be done off-line (you should explain how you have done it and why you have done it that way), but projection should be done programmatically.

Handin: Your code and the results in a report named **yourfirstname_lastname_studentno_hw2.pdf**.

Handin your code and results in a report document (pdf).