ECE 472 Robotics and Vision
Prof. K. Dana
Homework 2: Homography Estimation, Image Formation Pipeline

1. **Google Co-Lab** Write a python notebook to 1) read an rgb image called *testimg.png* and 2) display the image

2. Write a python notebook to "image" a simple object described by vertices (e.g., a simple house) in world coordinates from the view indicated by the extrinsic matrix below. . Use command *Line2D* to draw the 2D lines between the projected vertices. Do not use any 3d plotting commands. The projections should be handled by using the camera matrix (image formation pipeline) discussed in class.

   The calibration parameters are given as follows:

$$R = \begin{bmatrix} 0.707 & 0.707 & 0 \\ -0.707 & 0.707 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \quad t = \begin{bmatrix} -3 \\ -0.5 \\ 3 \end{bmatrix}$$

   .Therefore

$$M_{ext} = \begin{bmatrix} 0.707 & 0.707 & 0 & -3 \\ -0.707 & 0.707 & 0 & -0.5 \\ 0 & 0 & 1 & 3 \end{bmatrix}.$$

   Also $s_x = s_y = 1, f = 100$ and $o_x, o_y = 200, 200$ respectively. Therefore

$$M_{int} = \begin{bmatrix} -100 & 0 & 200 \\ -0 & -100 & 200 \\ 0 & 0 & 1 \end{bmatrix}$$

   Coordinate Frame Transformations

3. Coordinate frame B is described as follows: Start with B coincident with a known frame A. Rotate B about $\hat{z}_A$, by -45°. Translate B by the vector $[1, 1, 0]$ (written with respect to A).

   (a) Given ${}^{A}P = [1, 0, 2]$ what is ${}^{B}P$? That is, given a point that is $[0, 2, 0]$ when written with respect to the A frame, what is that point written with respect to the B frame?

4. Coordinate frame B is described as follows: Start with B coincident with a known frame A. Rotate B about $\hat{y}_A$, by 90°. Then Rotate B about $\hat{z}_A$ by 90° Translate B by the vector $[1, 1, 0]$ (written with respect to A).

   (a) What is $\hat{y}_B$ written with respect to the A frame?

   (b) What is $\hat{y}_A$ written with respect to the B frame?

(c) Given ${}^{A}P = [1, 0, 10]$ what is ${}^{B}P$? That is, given a point that is $[1, 0, 10]$ when written with respect to the A frame, what is that point written with respect to the B frame?

5. Coordinate frame B is described as follows: Start with B coincident with a known frame A. Translate B by the vector $[10, 0, 0]$ (written with respect to A). Rotate B about $\hat{y}_A$, by 90°.Then rotate about $\hat{z}_A$ by 45°.

   (a) What is $\hat{x}_B$ written with respect to the A frame?

   (b) What is $\hat{x}_A$ written with respect to the B frame?

   (c) Given ${}^{A}P = [0, 2, 0]$ what is ${}^{B}P$? That is given a point that is $[0, 2, 0]$ when written with respect to the A frame, what is that point written with respect to the B frame?

6. The origin of frame B with respect to A is $[2, 1, 1]$. The unit vectors of frame B with respect to A are $\hat{x}_B = [1, 0, 0]$, $\hat{z}_B = [0, 1, 0]$.

   (a) What is the the rotation matrix ${}^{A}R_B$?

   (b) Given ${}^{B}P = [0, 0, 2]$ what is ${}^{A}P$?

7. Consider Figure **??**.

   (a) What is the the rotation matrix ${}^{A}R_B$?

   (b) What is the translation vector ${}^{A}t_B$?

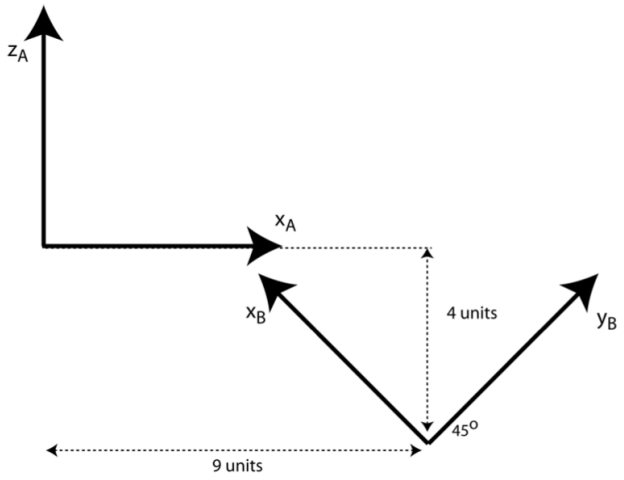

Figure 1: Coordinate frame A and B.

8. **Extra question. Required for Grad students**: Write a python program to estimate a homography between a frontal view and side view image of a planar surface (e.g. side of a building, sign, photo). The program input should also be corresponding

point pairs (Matlab's ginput is useful here). The program should estimate the homography using the DLT method. Report the homography parameters and warp the side view image to match a frontal view of the window. An example image is provided in *hpworld.png* (you may use a different image). External libraries for warping are allowed.

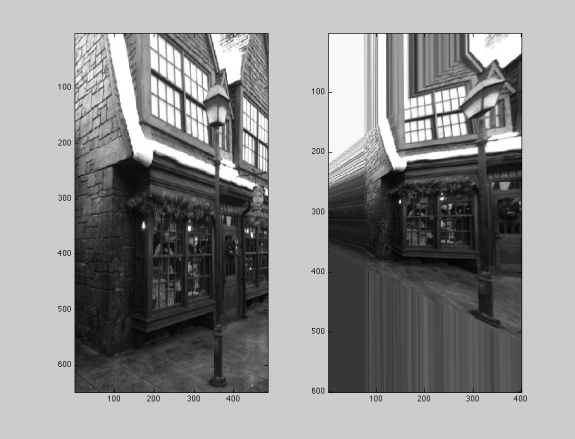

Figure 2: Remap the window region (left) to a frontal view (right) by estimating the appropriate homography and warping the image.