

## CS436/CS5310 Computer Vision - Assignment 1

Due: Tue 12 June, 2018 at 5:00 pm

Grade Scale: 100 points

1. [10 points] Point  $A = (1,1)^T$  is to be rotated about  $(-1,-1)^T$  by  $45^\circ$  in the counter clockwise direction. What is the location of this point after rotation? (Show all steps)
2. [10 points] Give the 2D homogeneous matrix for each of the transformations in parts a-c. Leave composite transformations in factored form:
  - a. Scale in the x-dimension by 2 and the y-dimension by 3 with fixed point  $(-3,1)$
  - b. Rotate by 135 degrees about the point  $(-4,-3)$
  - c. Reflect about the line  $y = -5$
  - d. Check your work on part c by applying the resulting matrix to the line segment from  $(-1,3)$  to  $(6,-2)$ . What are the new endpoints?
3. [10 points] Find a transformation matrix that transforms Figure 1 to 2

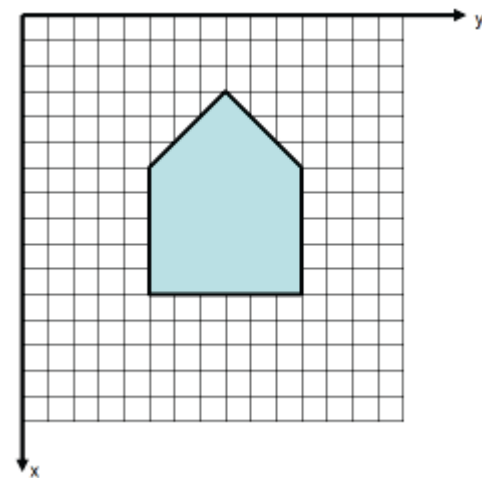


Figure 1

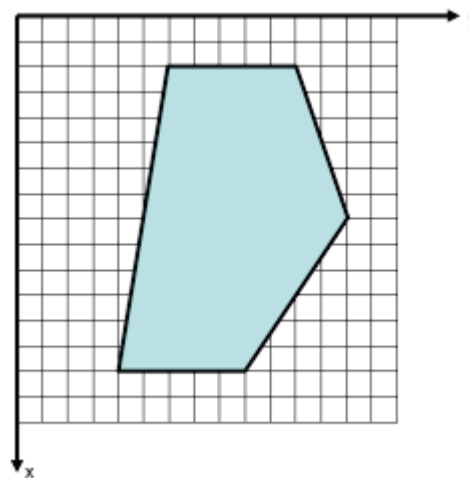


Figure 2

4. [10 points] The following 2D transformation is composed of a rotation followed by a scaling followed by a translation.

$$\begin{bmatrix} 0.6 & -1.04 & -20 \\ 0.693 & 0.4 & -50 \\ 0 & 0 & 1 \end{bmatrix}$$

- a) Find the rotation, scaling and translation matrices, which when multiplied in the order given above, will result in this transformation (Assume accuracy of up to 2 decimal places)
  - b) If the transformation was composed of a translation, followed by a rotation followed by a scaling, what would have been the answer to part a. above?
5. [15 points] Show that parallelism is preserved under a general affine transformation.

The following information applies for Questions 6 – 8.

The image shown below of a hut is taken by a perspective camera. The size of the image is 380 x 240 pixels. Several points are marked on the image. In the 3D world, point  $X$  lies in the middle of points  $D$  and  $E$ , and point  $F$  is directly above point  $X$ .

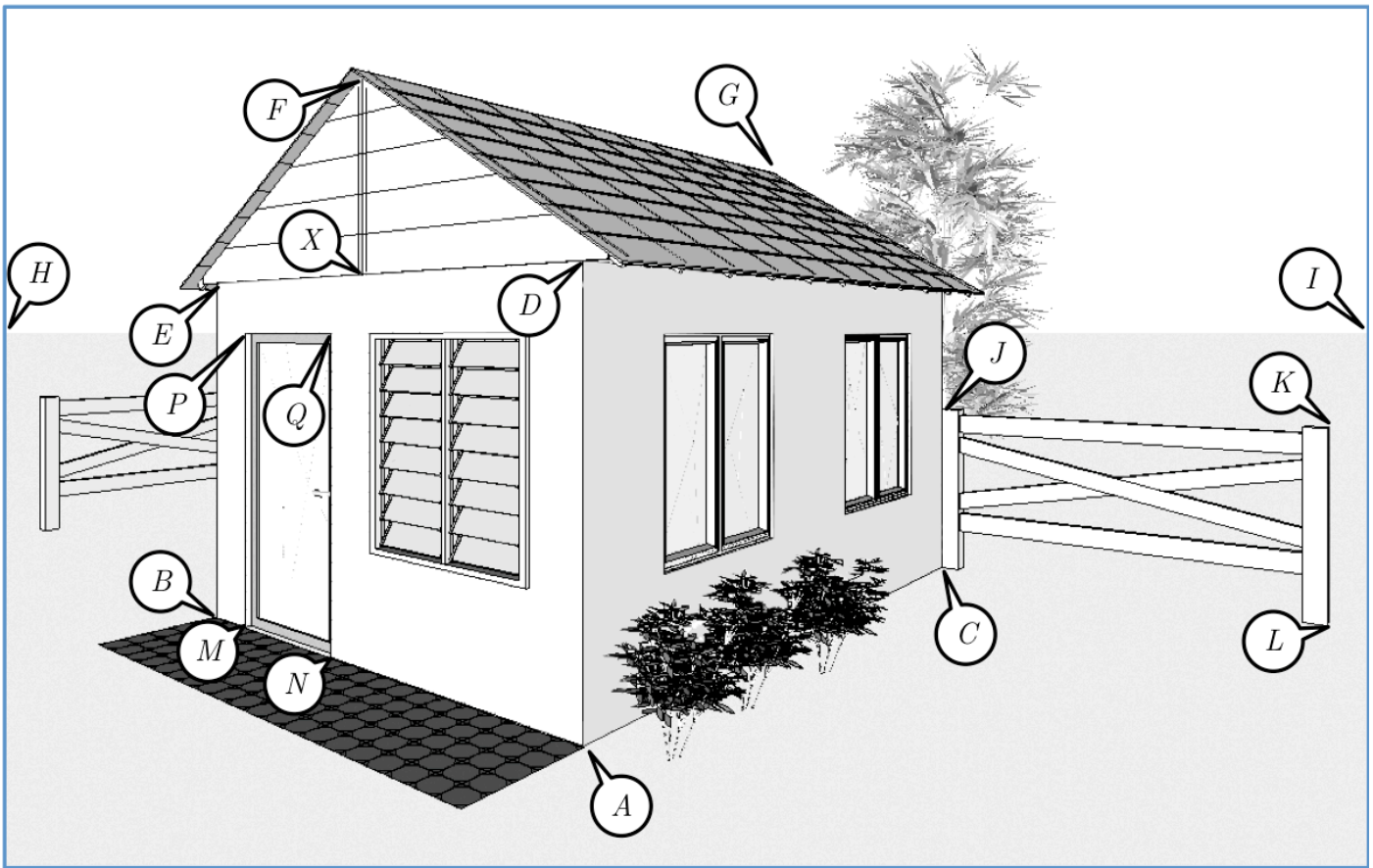


Image coordinates of these points are given in the table below.

| Point | A   | B   | C   | D   | E  | F  | G   | H  | I   | J   | K   | L   | M   | N   | P  | Q  |
|-------|-----|-----|-----|-----|----|----|-----|----|-----|-----|-----|-----|-----|-----|----|----|
| $x$   | 207 | 171 | 157 | 71  | 77 | 17 | 45  | 91 | 91  | 112 | 117 | 173 | 173 | 182 | 91 | 91 |
| $y$   | 160 | 58  | 261 | 160 | 58 | 96 | 214 | 1  | 380 | 261 | 370 | 370 | 66  | 90  | 66 | 90 |

The following additional information is available about the dimensions of the hut in 3D. The table below lists some line segments, and their corresponding dimensions in 3D world.

| Segment   | $AB$   | $AC$   | $AD$   | $CL$   | $CJ$   | $XF$   | $MN$  | $MP$   | $BM$  |
|-----------|--------|--------|--------|--------|--------|--------|-------|--------|-------|
| Dimension | 308 cm | 462 cm | 220 cm | 230 cm | 152 cm | 106 cm | 88 cm | 187 cm | 33 cm |

6. [15 points] Answer the following questions:

- Is length  $XE$  equal to length  $DX$  in the image? (YES/NO). Justify your answer.
- Find the coordinates of the point  $X$  marked in the image.
- Verify, *through numerical calculation*, whether the horizon line is drawn in the correct location in the image.

7. [15 points] Compute a homography which will rectify the fence  $CJKL$

8. [15 points] Assume that the origin of the world coordinates is at point  $A$ . Also assume that the  $X$ -axis of the 3D world is in the direction  $AC$ , the  $Y$ -axis in the direction  $AB$  and the  $Z$ -axis in the direction  $AD$ . Compute the vanishing points (i.e. points at infinity, projected into the image space) in the direction of the  $X$ -axis,  $Y$ -axis and  $Z$ -axis.