CENG 391 Introduction to Image Understanding

17 November, 2017

Homework 3

Due Date: 07 December 2017, 23:55

Programming Assignment — Warp Affine

In this assignment, you should write a Python code for warping with affine deformation and necessary comments about the specific steps that are indicated with **COMMENT** sign.
The affine deformation matrix is computed by camera position parameters as follows :

$$A = \lambda \begin{bmatrix} cos\psi & sin\psi \\ -sin\psi & cos\psi \end{bmatrix} \begin{bmatrix} t & 0 \\ 0 & 1 \end{bmatrix} where, t = cos\theta. \tag{1}$$

The camera position parameters are represented in Figure 1 and can be defined as follows :

- Scale (λ in [1]) is the zoom parameter,
- In-plane rotation angle (ψ in [1]) represents rotation around an axis that is perpendicular to the object plane,
- Tilt amount (θ in [1]) is the angle between the normal of the image plane and the optical axis of the camera.

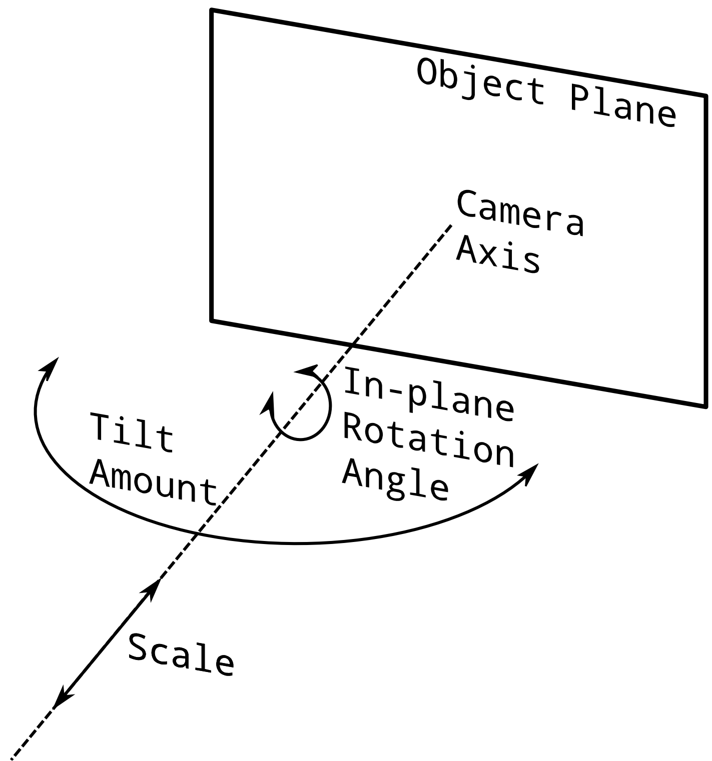

Figure 1: Camera position parameters.

Once the affine deformation matrix is constructed, reference image is projected into the warped image. As a first, size of the output image should be computed by multiplying four corners of the reference image with the affine deformation matrix. Then, homography is obtained as follows:

$$H = \begin{bmatrix} 1 & 0 & w_w/2 \\ 0 & 1 & w_h/2 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_{00} & A_{01} & 0 \\ A_{10} & A_{11} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -r_w/2 \\ 1 & 0 & -r_h/2 \\ 0 & 0 & 1 \end{bmatrix}, where \tag{2}$$

w_w and w_h represent the width and height of the warp image respectively.

r_w and r_h represent the width and height of the reference image respectively.

COMMENT-1: Please give comment on why we multiply affine matrix with two matrices from its left side and right side to obtain the homography matrix. Indicate the reason for multiplying either of the matrices.

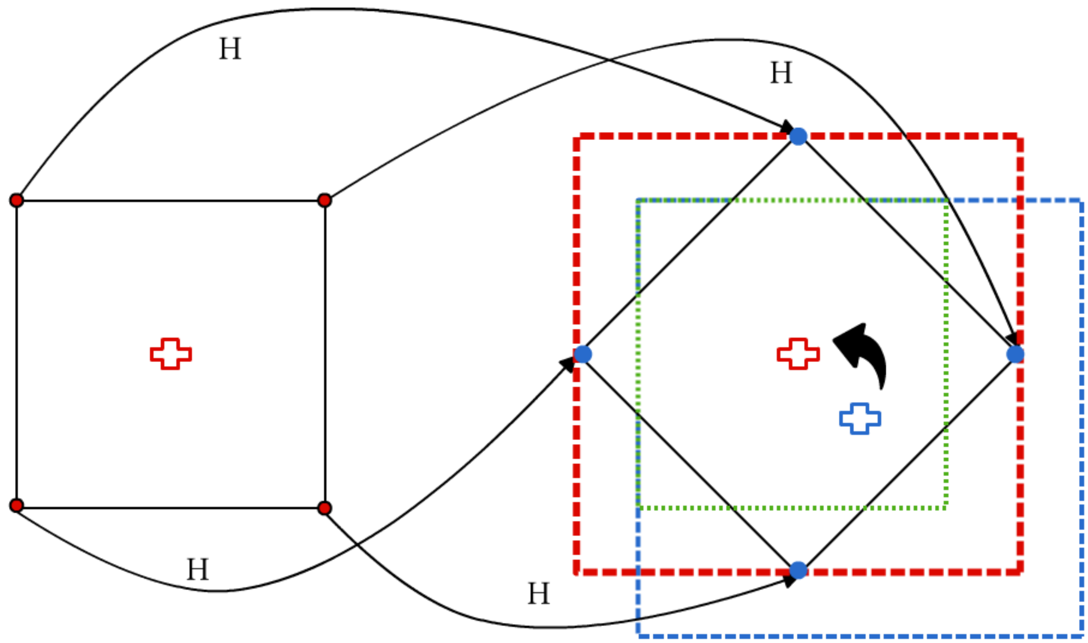

Figure 2: Constructing warped image. Green dotted rectangle represents the size of the warped image which should be computed by warping the corners of the reference image to the warped image. Blue dotted rectangle shows resized warped image. The red plus signs represent the image center in both the reference and the output image. Then, the center of the warped image is moved from the blue to red plus sign.

Once the homography is computed from the reference image to the warped image, each pixel of the warped image is transformed with inverse of the homography as it is shown in Figure 3

Finally, compute the intensity of each pixel belonging to warped image by applying bilinear interpolation.

COMMENT-2: Please give comment on why we transform warped image to the reference image with inverse homography as it is shown in Figure 3.
COMMENT-3: Please give comment on why we use bilinear interpolation to compute intensity values of the warped image. Is there any difference if we use nearest-neighbour interpolation which uses intensity value of nearby reference pixel for the warped pixel value? Explain briefly.

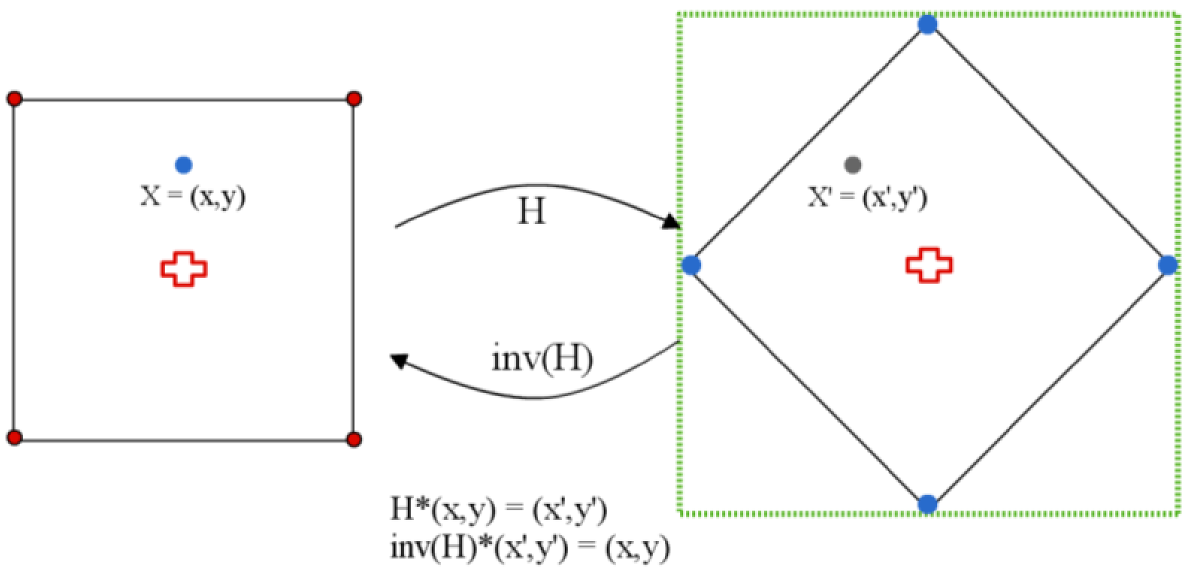

Figure 3: Geometrical relation between the reference image and the warped image. H represents the homography from the reference to the warped image.

In this assignment, expected output is shown in Figure 5 with camera position parameters given in the below:

- $\lambda = 0.5$,
- $\psi = 30°$,
- $\theta = 50°$.

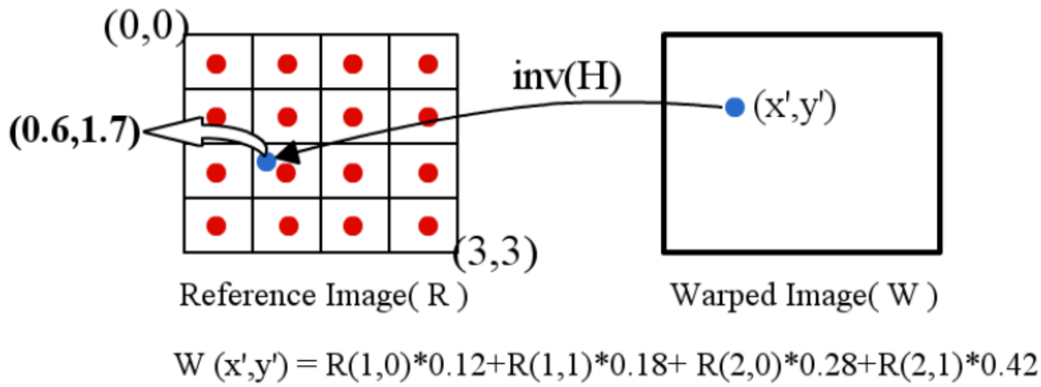

Figure 4: Applying bilinear interpolation.

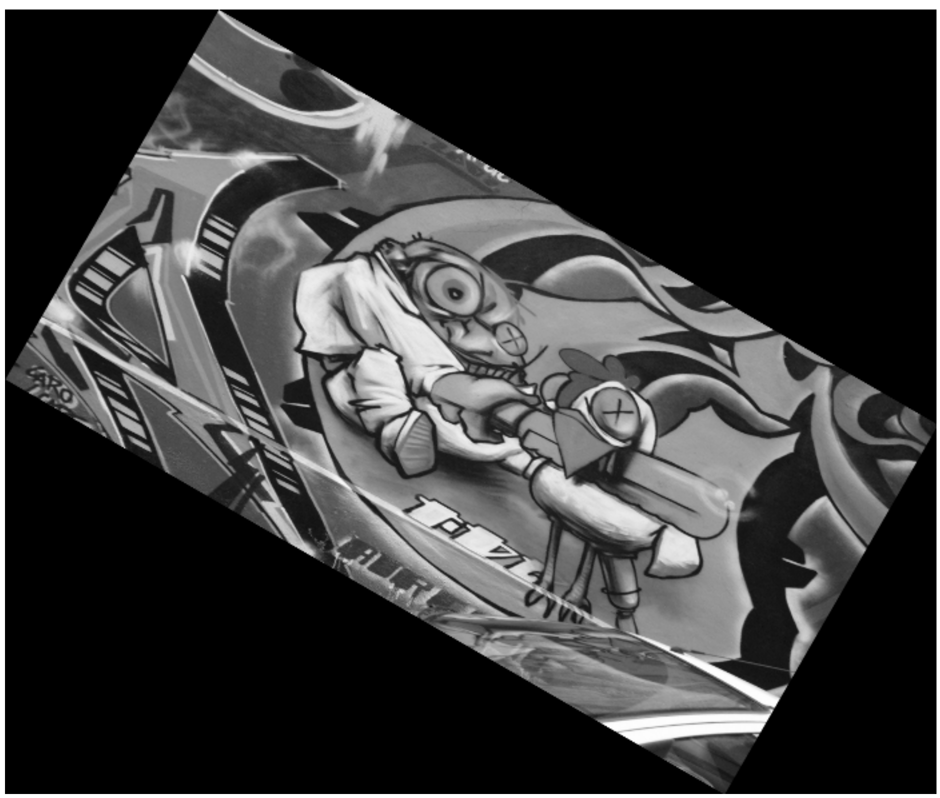

Figure 5: Expected output.

References

[1] J.-M. Morel and G. Yu. Asift: A new framework for fully affine invariant image comparison. *SIAM J. Img. Sci.*, 2(2):438–469, Apr. 2009.