CENG 391 Introduction to Image Understanding

17 November, 2016

Homework 3

Due Date: 29 November 2016, 23:55

Programming Assignment — Warp Affine

In this assignment, you should write C++/Python code for warping with affine deformation. 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.

Once the affine deformation matrix is constructed, the reference image is projected into the warped image by a translation around the image center as it is shown in Figure 2. As a first, size of the output image should be

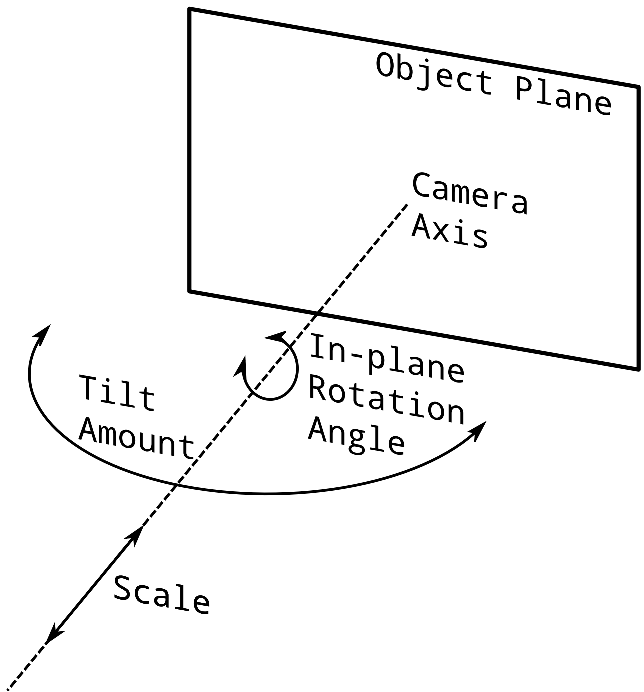

Figure 1: Camera position parameters.

computed by multiplying four corners of the reference image with the affine deformation matrix. Then, in order to have translation around the center of the reference image following computation should be done to obtain homography:

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

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.

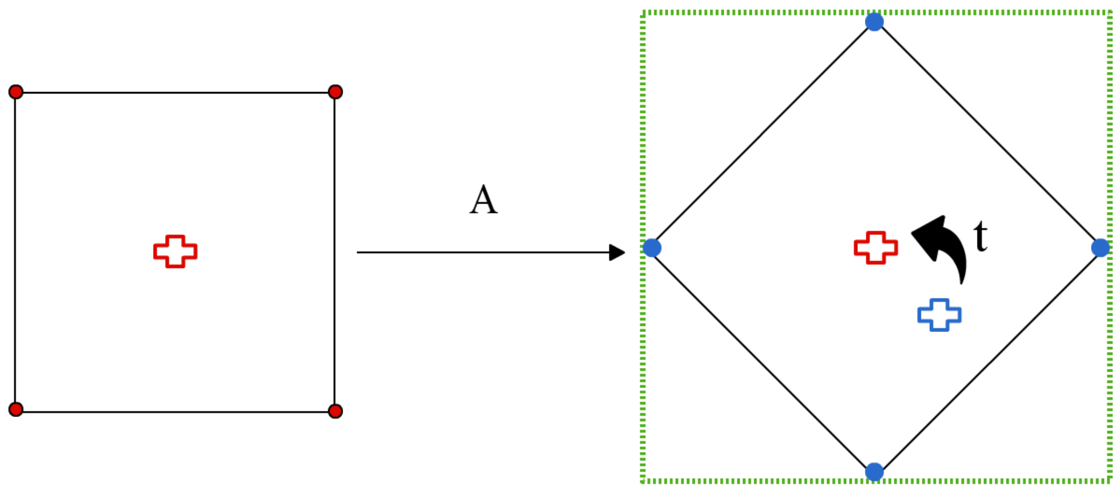

Figure 2: Constructing warped image. Green dotted rectangle represents the size of the warped image which should be computed by warping the corners of the reference image to the warped image. The red plus signs represent the image center in both the reference and the output image. After translation, 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. Then, compute the intensity of the corresponding pixel by applying bilinear interpolation which is the method for interpolating linearly in both directions as it is shown in Figure 4.

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

- $\lambda = 0.5$,
- $\psi = 45°$,
- $\theta = 10°$.

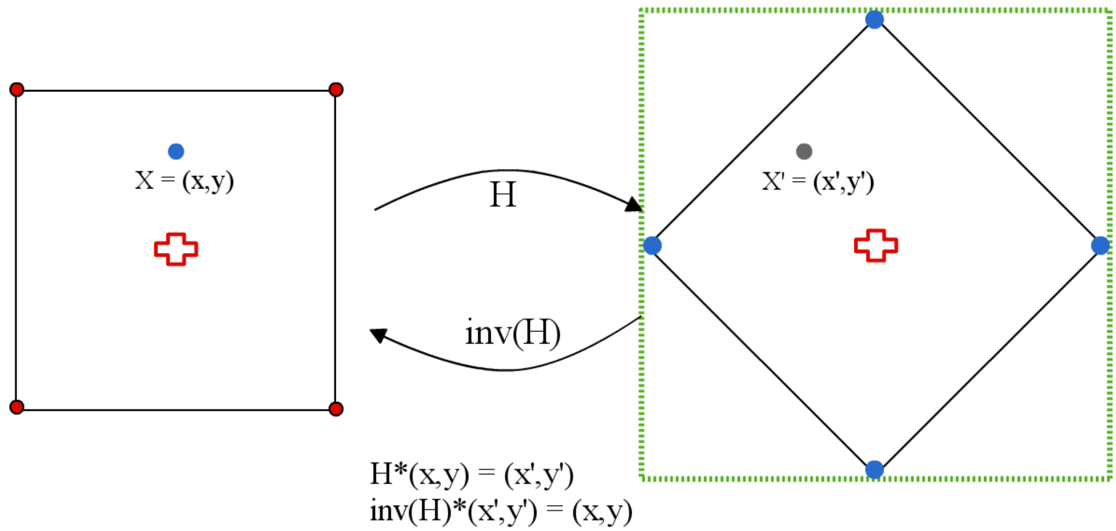

Figure 3: Geometrical relation between the reference image and the warped image. H represents the homography from the reference to the warped image.

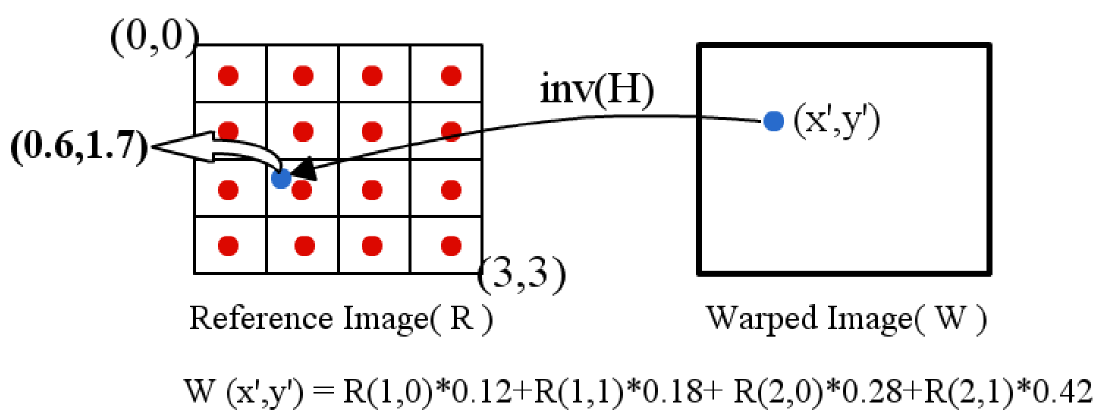

Figure 4: Applying bilinear interpolation. The output intensity value should be computed by weightining sum based on the spatial distances to its four neighbours.

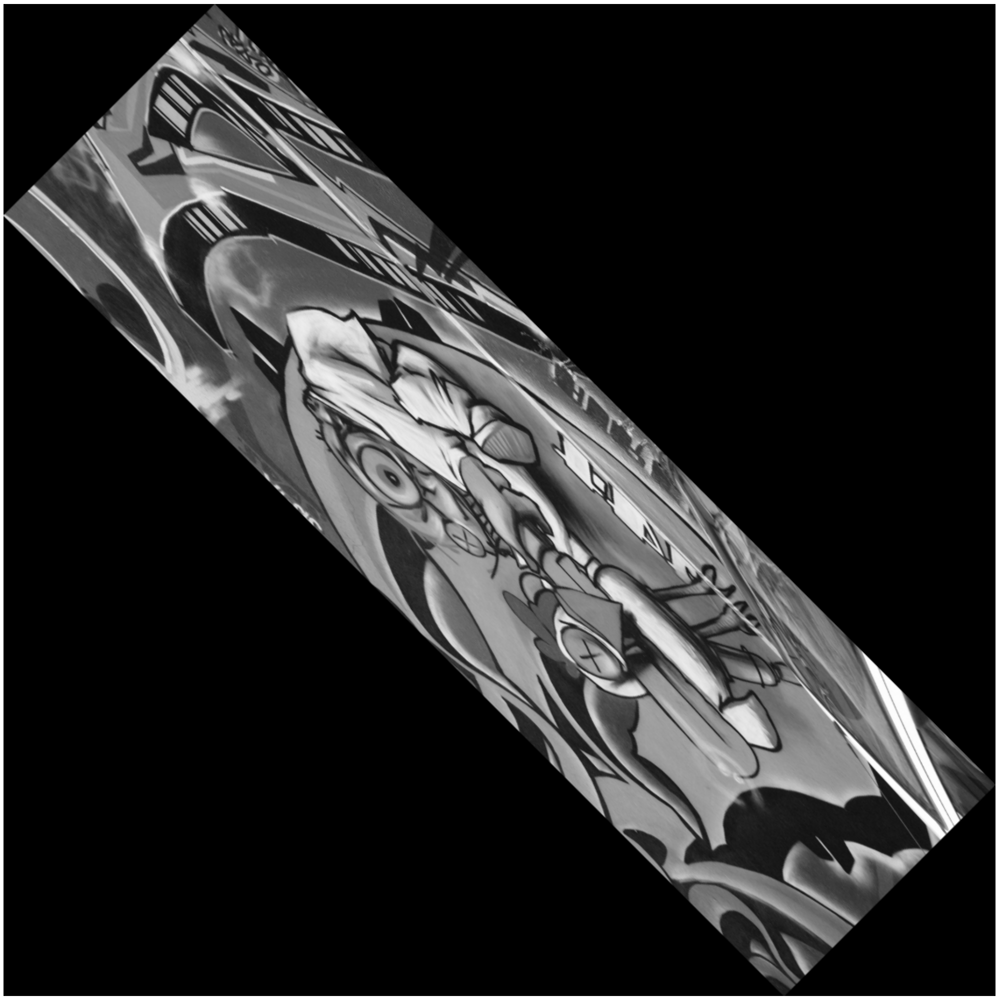

Figure 5: Expected output.

References

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