National Tsing Hua University
Department of Electrical Engineering
EE3662 Digital Signal Processing Laboratory, Fall 2022

Lab 9 Pixel Array Manipulation

Assigned on Nov 21, 2022
Due by Nov 28, 2022

Overview

The goal of this homework is to help you get familiar with pixel array manipulation in MATLAB. You will learn how to read and write image files in MATLAB. Then, you will need to write some functions to manipulate pixel array, i.e., RGB to YUV, image flipping, image rotation, and image resize in this lab.

Tutorials

1. Each image includes three channels R, G, B, and the size of each channel is height∗width.
2. Use **`imread()`, `imshow()` and `imwrite()`** function to read, show and save images.
   `I = imread(filename)`, **`I`** is a 3 dimension matrix,
   `R = I(:, :, 1)`, **`G = I(:, :, 2)`**, **`B = I(:, :, 3)`**.
   Tips: **`I(1:50, :, 1)`** ⇒ **`1:50`** means 1 to 50, and **`:`** means 1 to image width.
3. **`a = 3`** vs **`a = 3;`** ⇒ Result is shown on command window without **`;`**.
4. Press **`ctrl+Enter`** to run code between **`%%`**.
5. Press **`ctrl+c`** to stop running.

Details

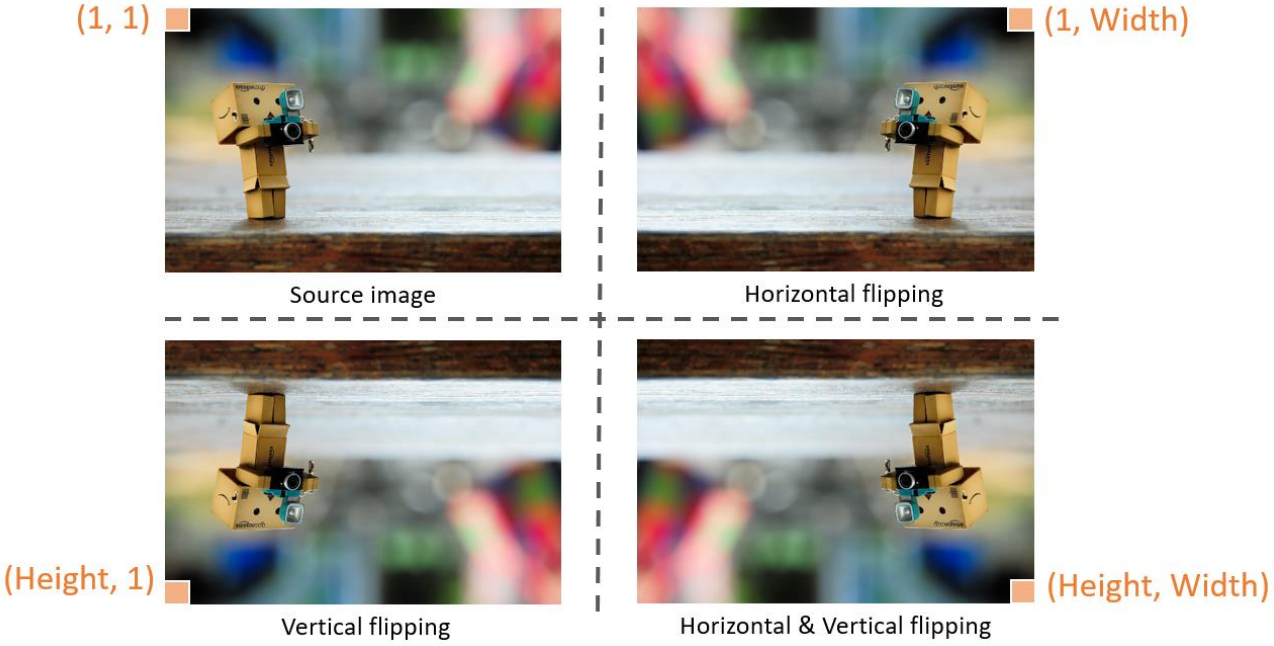
1. RGB to YUV (15%)

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.5 \\ 0.5 & -0.419 & -0.081 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 0 \\ 128 \\ 128 \end{bmatrix}$$

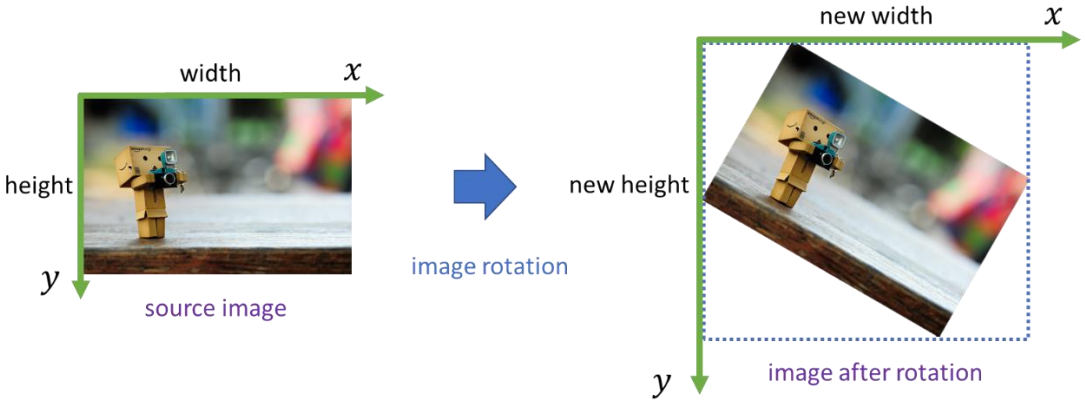
Use coefficients provided above, and do not use rgb2ycbcr() function.

2. Image flipping (10%)

Implement three kinds of flipping.

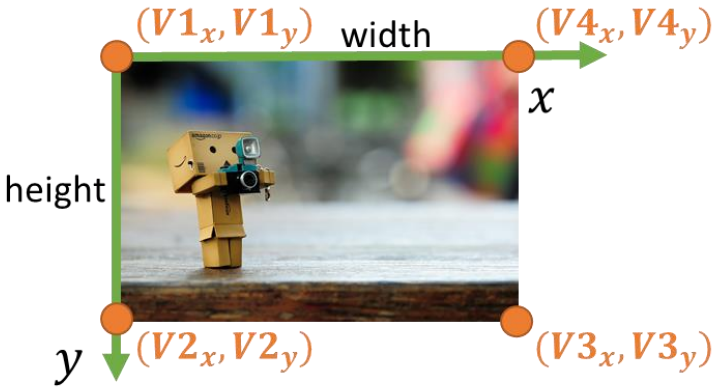


2. Image rotation (15%)

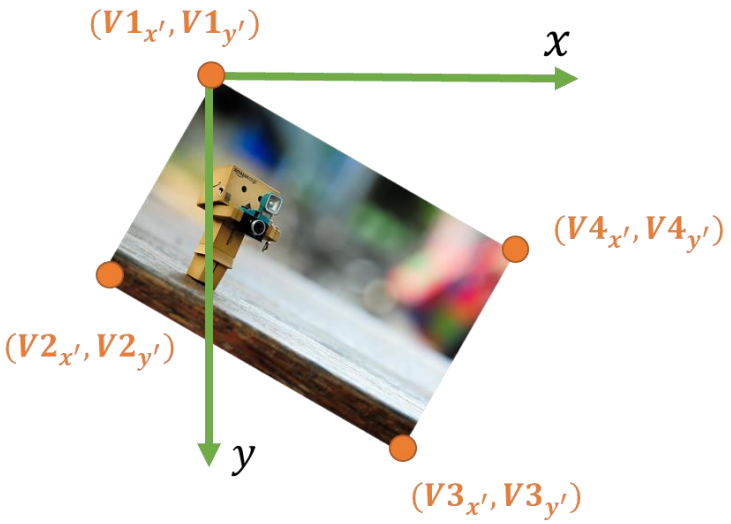


$$Rotation\ matrix: \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

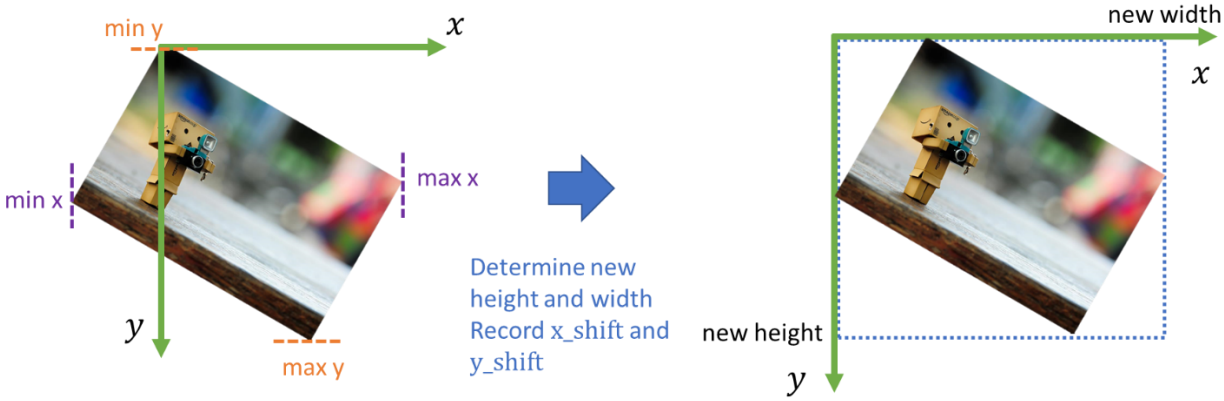
(1) Record vertices.



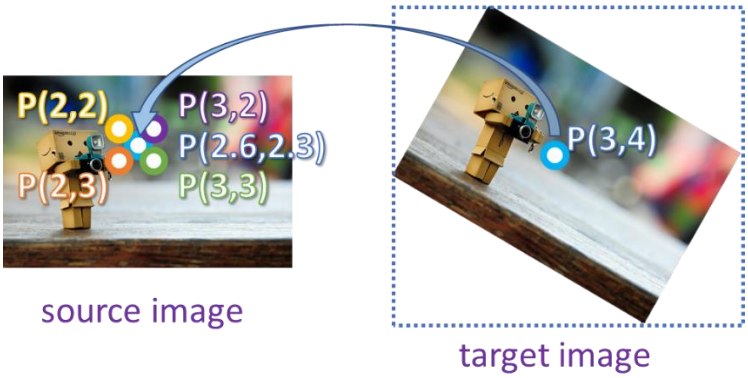
(2) Use rotation matrix to get rotated vertices.



(3) Get new height and width to create new image with zero matrix.

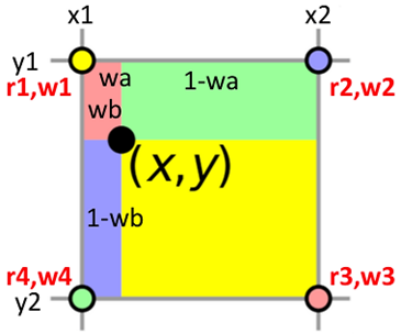


(4) Backward warping.



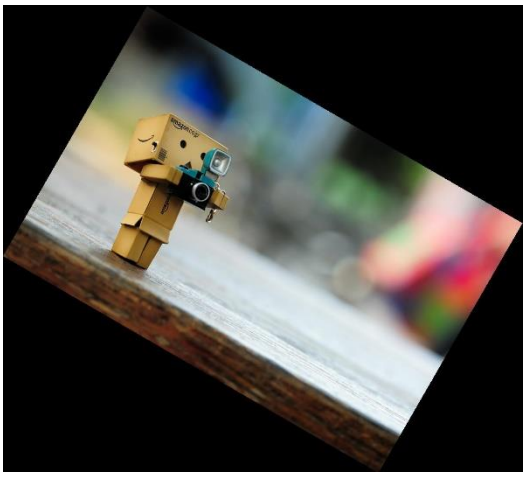
(5) Bilinear interpolation.

$$
\begin{aligned}
\mathrm{wa} &= (\mathrm{x} - \mathrm{x1}) \,/\, (\mathrm{x2} - \mathrm{x1}) \\
\mathrm{wb} &= (\mathrm{y} - \mathrm{y1}) \,/\, (\mathrm{y2} - \mathrm{y1}) \\
\mathrm{w1} &= (1 - \mathrm{wa}) * (1 - \mathrm{wb}) \\
\mathrm{w2} &= \mathrm{wa} * (1 - \mathrm{wb}) \\
w3 &= wa * wb \\
\mathrm{w4} &= (1 - \mathrm{wa}) * \mathrm{wb}
\end{aligned}
$$



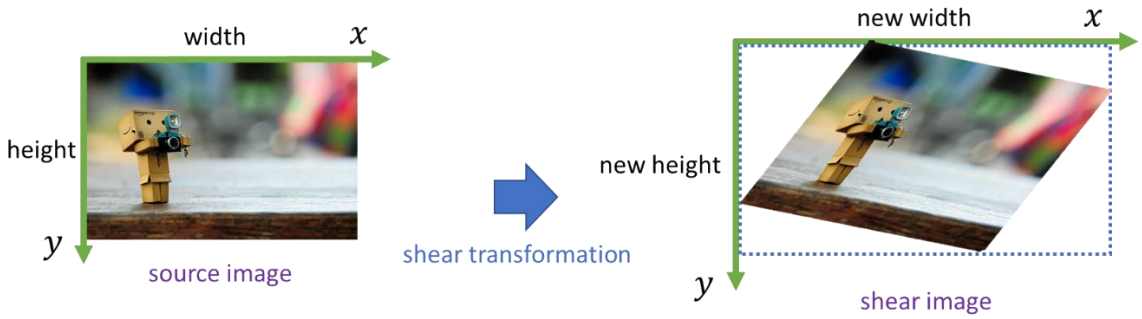
$$
\begin{aligned}
\mathrm{r(x,y)} &= \mathrm{r1} * \mathrm{w1} + \mathrm{r2} * \mathrm{w2} + \mathrm{r3} * \mathrm{w3} + \mathrm{r4} * \mathrm{w4} \\
\mathrm{g(x,y)} &= \mathrm{g1} * \mathrm{w1} + \mathrm{g2} * \mathrm{w2} + \mathrm{g3} * \mathrm{w3} + \mathrm{g4} * \mathrm{w4} \\
\mathrm{b(x,y)} &= \mathrm{b1} * \mathrm{w1} + \mathrm{b2} * \mathrm{w2} + \mathrm{b3} * \mathrm{w3} + \mathrm{b4} * \mathrm{w4}
\end{aligned}
$$

(6) Result image.



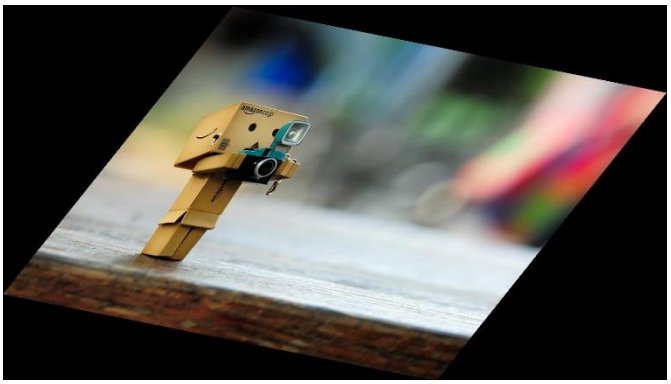
Do not use imrotate() function.

3. Shear Transformation (10%)



$$Shear\ transformation: \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & shear\_x \\ shear\_y & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

(1) Record vertices.
(2) Use transformation matrix to get new vertices.
(3) Get new height and width to create new image with zero matrix.
(4) Backward warping.
(5) Bilinear interpolation.
(6) Result image.

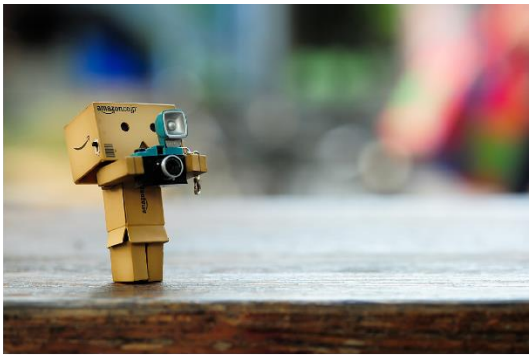


Do not use imwarp() function.

5. Image scaling (10%)

Use the similar method as image rotation and shear transformation to conduct image resize function. However, try to use **nearest-neighbor interpolation** instead of **bilinear-interpolation** in the implementation.

Input image



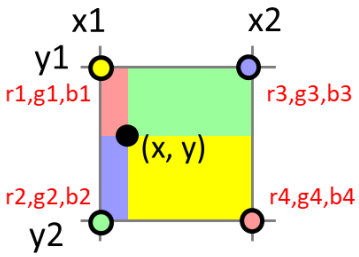
1.5x

0.6x

(1) To do nearest-neighbor interpolation, interpolate $P(x, y)$ from the nearest point. For example,

$$r(x, y) = r1;\ g(x, y) = g1;\ b(x, y) = b1$$

in the following figure.



Do not use imresize() function.

Report

1. (7%) Show the results in each part with two images. One is given by TA and the other is your own image.

2. (10%) Try to use the forward warping method mentioned above to implement image rotation. Specify the flow of your implementation and show your results. Please include your code in "Lab9/code/".

3. (10%) There are two ways for image warping. One is forward warping and the other is backward warping. What are the differences between them? Try to describe the differences subjectively and objectively.

4. (10%) Try to implement at least one other method for image flipping, image rotation or image resize. Specify your method and show the results. Compare the differences between the original method in this lab and your proposed method. Please include your code in "Lab9/code/".

5. (3%) Conclusion.

Deliverable and file organization

Directory	Filename	Description
Lab9/code/	*.m	All MATLAB codes
Lab9/data/	*.png / *.jpg	Your own source image
Lab9/report/	report_10xxxxxxx.pdf	Your report
Lab9/results/	*.png / *.jpg	Your results

Please organize your files according to the above table and compress it as Lab9_10xxxxxxx.zip in ZIP format. (P.S. 10xxxxxx is your student ID)

Wrong file delivery, wrong file organization or wrong file naming will get 5% punishment.