Contents

DIPUM 3rd edition | Project 4 - Chapter 6 on Transformations Sierpinski triangle Author: Ernesto Colon Date: 2.20.21 ECE419 - Digital Image Processing @ The Cooper Union

```
clc; clear all; close all
```

This project explores compositions of affine transforms and implementing rotation as three successive shearing operations: a horizontal shear, followed by a vertical shear, followed by another horizontal shear. This can sometimes be of practical interest because each shearing operation can be implemented by shifting and interpolating image pixels in only one direction. For a rotation angle of θ, the three affine shear matrices are:

$$T_1 = \begin{bmatrix} 1 & 0 & 0 \\ \alpha & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$T_2 = \begin{bmatrix} 1 & \beta & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$T_3 = \begin{bmatrix} 1 & 0 & 0 \\ \gamma & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

where $\alpha = \gamma = -tan(\theta/2)$ and $\beta = sin(\theta)$

part a Make a 4 x 2 matrix containing the four vertices, (0.5, 0.5), (-0.5, 0.5), (-0.5, -0.5), and (-0.5, -0.5), of a unit square centered at the origin. Plot the square containig these vertices.

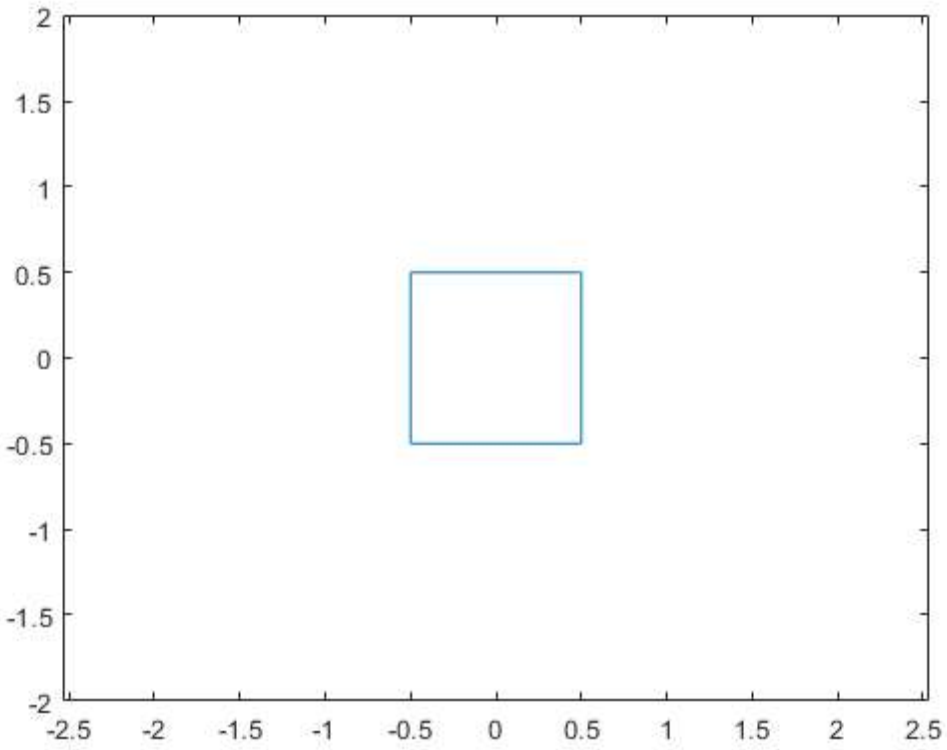
```
unit_square = [0.5 0.5; -0.5 0.5; -0.5 -0.5; 0.5 -0.5; 0.5 0.5]

% plot the unit square
figure
plot(unit_square(:,1), unit_square(:,2), '-')
axis([-2 2 -2 2], 'equal')
hold on
```

```
unit_square =

    0.5000    0.5000
   -0.5000    0.5000
   -0.5000   -0.5000
    0.5000   -0.5000
```

```
    0.5000    0.5000
```

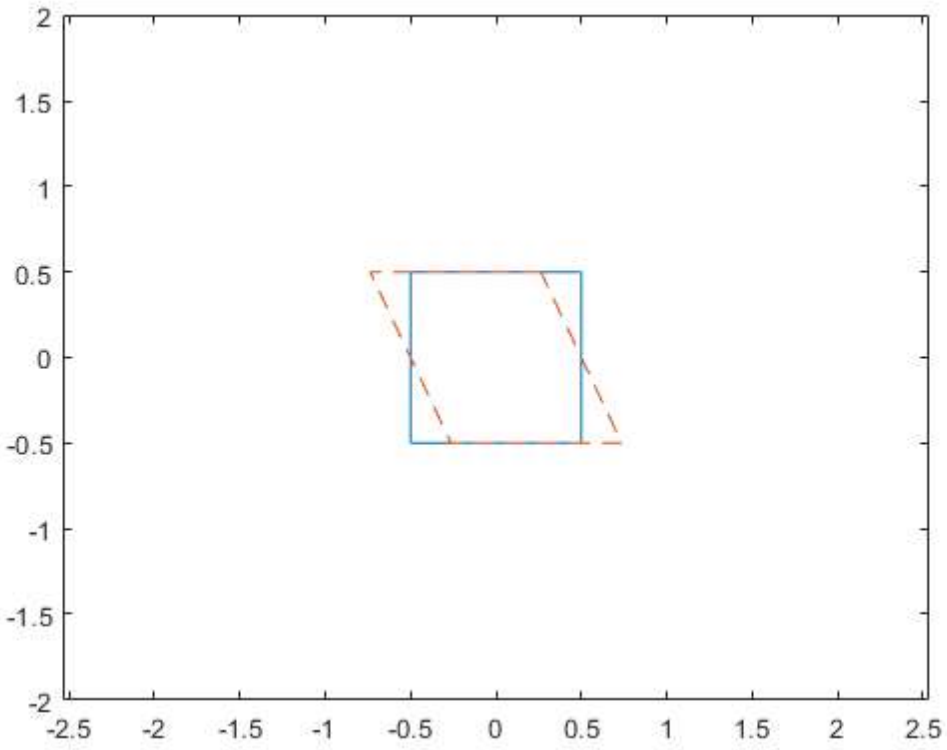


part b Make three affine2d objects using the three affine transform matrixes shown aboe and $\theta = 70°$. In three steps, apply these affine transforms successively to the vertices of the square and superimpose plots

```
theta = 70;
xfm_shear_1 = affine2d([1 0 0; -tan(theta/2) 1 0; 0 0 1]);

% apply transformation to vertices of unit square
unit_square_xfm_1 = transformPointsForward(xfm_shear_1, unit_square);

% plot the rotated square
plot(unit_square_xfm_1(:,1), unit_square_xfm_1(:,2), '--')
hold on
```

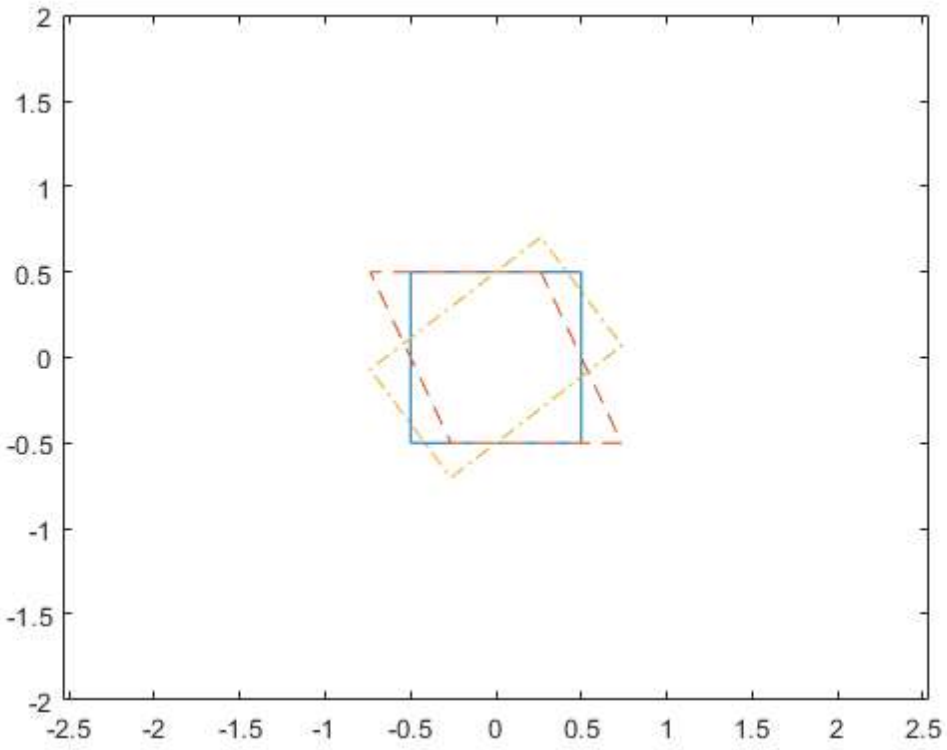


second shear transformation

```
xfm_shear_2 = affine2d([1 sin(theta) 0; 0 1 0; 0 0 1]);

% apply transformation to vertices of unit square
unit_square_xfm_2 = transformPointsForward(xfm_shear_2, unit_square_xfm_1);

% plot the rotated square
plot(unit_square_xfm_2(:,1), unit_square_xfm_2(:,2), '-.')
hold on
```



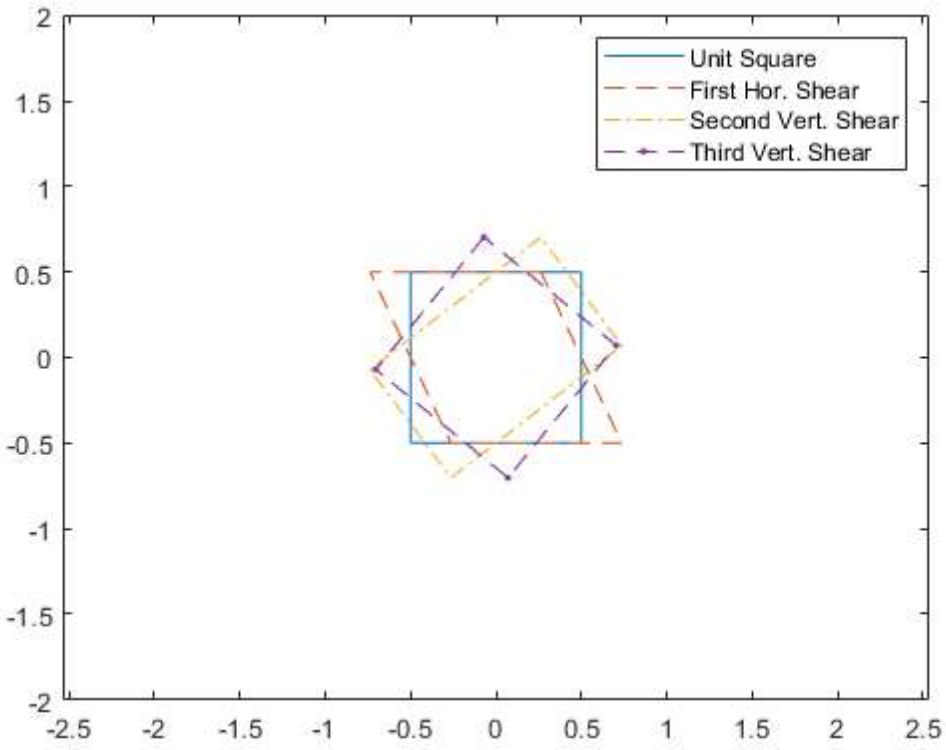
third shear transformation

```
xfm_shear_3 = affine2d([1 0 0; -tan(theta/2) 1 0; 0 0 1]);

% apply transformation to vertices of unit square
unit_square_xfm_3 = transformPointsForward(xfm_shear_3, unit_square_xfm_2);

% plot the rotated square
plot(unit_square_xfm_3(:,1), unit_square_xfm_3(:,2), '--.')
hold on

legend('Unit Square','First Hor. Shear','Second Vert. Shear','Third Vert. Shear')
```



part c

successively apply the three affine trasnformations to the image 'apple-hill-2013.png' using imwarp.

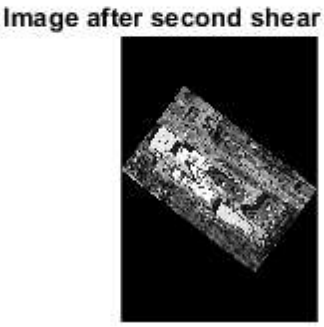
```
img_appl_hill = imread('../images/apple-hill-2013.png');
figure
subplot(2,2,1)
imshow(img_appl_hill)
title("Original Image")
```

apply first affine transformation

```
img_shear_hor_1 = imwarp(img_appl_hill, xfm_shear_1);
subplot(2,2,2)
imshow(img_shear_hor_1)
title("Image after first horizontal shear")
```

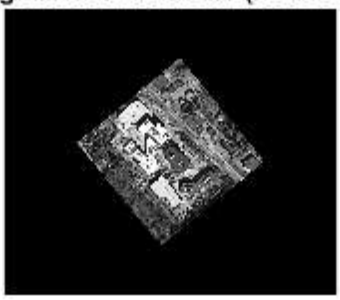
apply seccond affine transformation

```
img_shear_ver_2 = imwarp(img_shear_hor_1, xfm_shear_2);
subplot(2,2,3)
imshow(img_shear_ver_2)
title("Image after second shear (vertical)")
```



apply third affine transformation

```
img_shear_hor_3 = imwarp(img_shear_ver_2, xfm_shear_3);
subplot(2,2,4)
imshow(img_shear_hor_3)
title("Image after third shear (horizontal)")
```



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