COMS W4731 Computer Vision Hw1

Name: Xiaoning Wan

UNI: xw2501

Written Assignments

Problem 1

a. The image of the disk has a shape of **circle**.
   Let (x, y, z) denote for the coordinate of a point p on the disk, where z represents the distance from the pinhole to the disk plane and (x, y) represents the coordinate of point p on the disk plane.
   Let (x', y', z') denote for the coordinate of the relative point p' (p' is the projection of p), where z' represents the distance from the pinhole to the image plane and (x', y') represents the coordinate of p' on image plane.
   The relationship of (x, y, z) and (x', y', z') is

$$\frac{x'}{x} = \frac{y'}{y} = -\frac{z'}{z}$$

$$x' = -\frac{z'}{z}x \qquad y' = -\frac{z'}{z}y$$

   As the disk plane is parallel to the image plane, the coordinate of all points on the disk is scaled $-\frac{z'}{z}$ while the shape remains a circle.

b. Let d' denote for the diameter of the image,
   z' denote for the distance from pinhole to image plane,
   z denote for the distance from pinhole to disk plane,
   d denote for the distance from pinhole to disk plane.
   The relationship of these four is

$$\frac{d'}{d} = \frac{z'}{z}$$

$$d' = d\frac{z'}{z}$$

   Now that z is doubled, according to their relationship, d' is halved. Thus, the area of the image is a quarter of previous area. The area of image is 0.25mm^2

c. The image of the sphere has a shape of **circle or ellipse**.

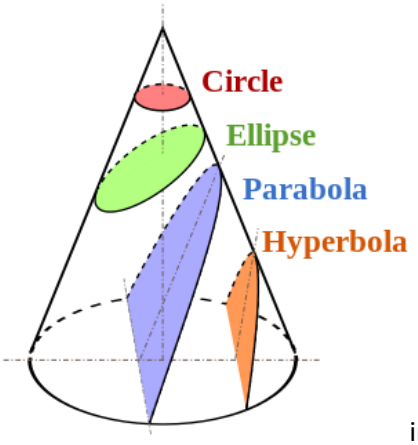


image 1(from wikipedia)

i. If the line of the center of sphere and the pinhole is vertical to the image plane, the shape of the sphere is a circle. According to image 2, in this case, the shadow part is a cone and the image of the sphere is the same as the red area given in image 1, which is a circle.

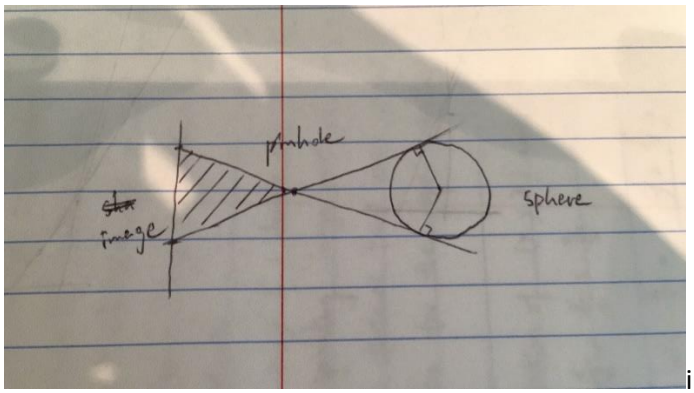


image 2

ii. If the line of the center of sphere and the pinhole is not vertical to the image plane, the shape of the sphere is an ellipse. According to image 3, in this case, the shadow part is a cone and the image of the sphere is the same as the green area given in image 1, which is an ellipse.

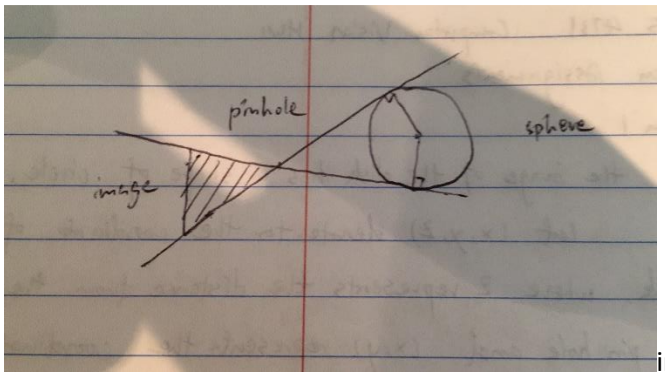


image 3

Problem 2

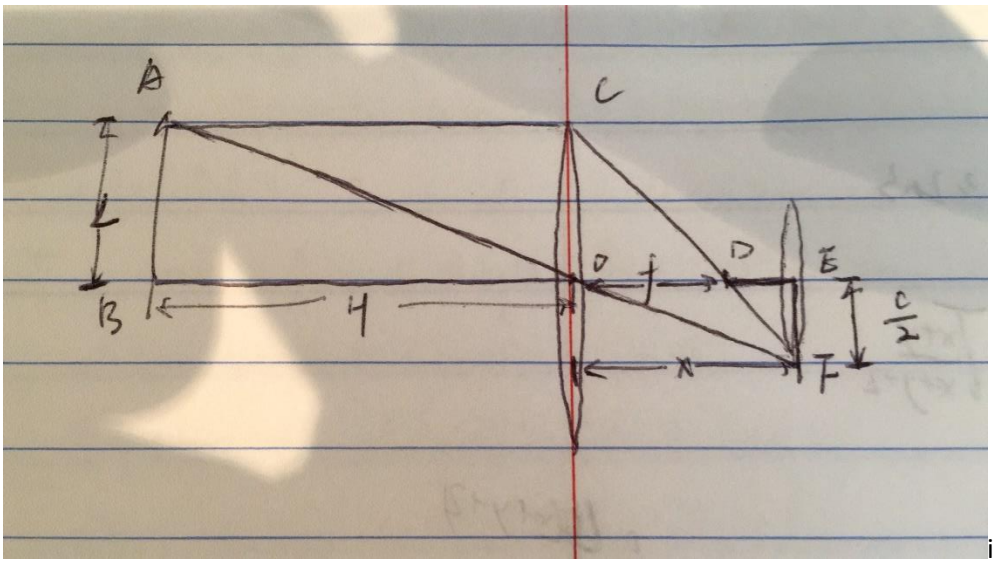


image 4

Analyze image 4, $L = \frac{f}{2N}$

Triangle COD is similar to triangle FED. Thus $\frac{\frac{c}{2}}{x-f} = \frac{L}{f} = \frac{1}{2N}$, $x = f + Nc$

Triangle ACO is similar to triangle FEO. Thus $\frac{x}{\frac{c}{2}} = \frac{H}{L} = \frac{2HN}{f}$,

$$H = \frac{fx}{Nc} = \frac{f}{Nc}(f + Nc) = \frac{f^2}{Nc} + f$$

Problem 3

a. Analyze image 5

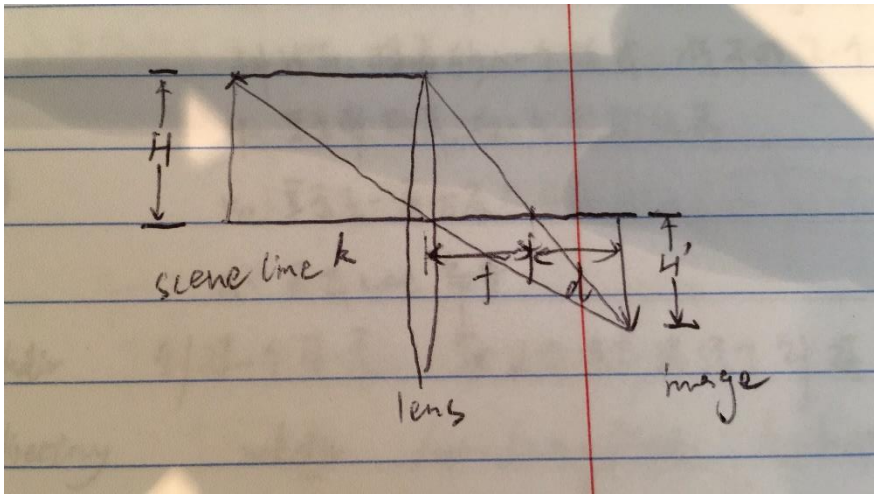


image 5

$$\frac{H}{H'} = \frac{k}{f+d} = \frac{f}{d}$$

$$d = \frac{f^2}{k-f}$$

$$distance = d + f = \frac{kf}{k-f}$$

At the distance $\frac{kf}{k-f}$ will a focused image be formed.

b. For a point p on scene line with a coordinate (x, y), there is a relative image point p' with coordinate (x', y').
Rewrite scene line as $y = a(x-k)$
According to (a), we have $-\frac{y'}{y} = \frac{x'}{x}$
Thus, $y' = -\frac{y}{x}x' = -a\left(1-\frac{k}{x}\right)x' = -a\left(1-\frac{k(x'-f)}{x'f}\right)x' = -a\left(x'-\frac{kx'}{f}+k\right) = -a\left(\frac{f-k}{f}\right)x' - ak$
y' is a linear function of x', which means the image is a tilted line.

c. As shown in (b), $\frac{dy}{dx} = a = \frac{1}{\tan\theta}$,
$\frac{dy'}{dx'} = -a\left(\frac{f-k}{f}\right) = \frac{1}{\tan\varphi}$, $a = \frac{1}{\tan\varphi}\frac{f}{k-f}$
Obviously, $\tan\varphi = \frac{f}{k-f}\tan\theta$

Programming Assignments

In order to give a clear view of the relationship of script and output, each output is given after the relative code, and is marked in red.

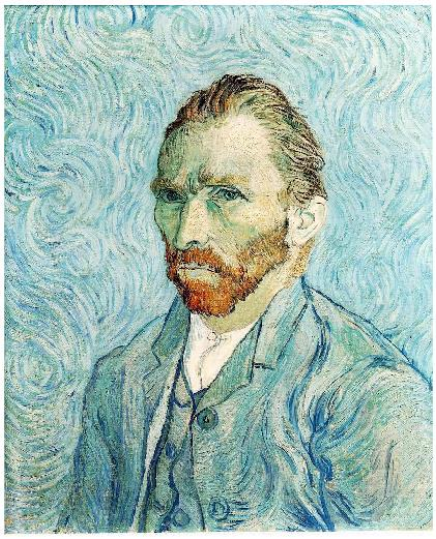
Note that all the graphs are not in their origin size due to space limit.

Walkthrough 2

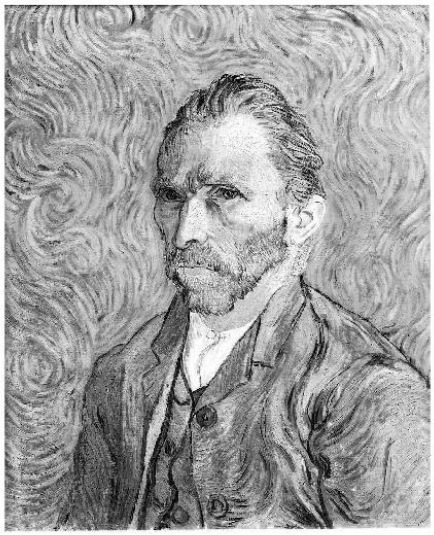
Code and result:

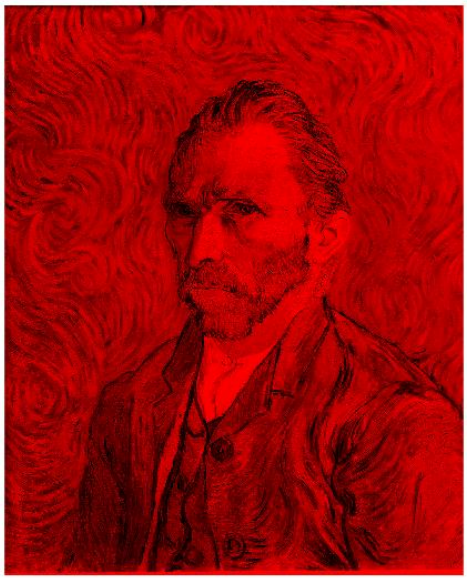
```
% ------------------------------------------------------------------------
----
% Part 2 - Create a Vincent van Gogh collage
% ------------------------------------------------------------------------
----

% Load the image "Vincent_van_Gogh.png" into memory
img = imread('Vincent_van_Gogh.png');

% Note the image is of the type uint8,
% and the maximum pixel value of the image is 255.
class(img)
      output:
            ans = unint8
max(img(:))
      output:
            ans = 255
```

```
% uint8 is memory efficient. Since we will perform some arithmetic
operations
% on the image, uint8 needs to be used with caution. Let's cast the
image
% to double.
img = im2double(img);

class(img)
      output:
            ans = double
max(img(:))
      output:
            ans = 1

% Display the image
figure, imshow(img);
      output:
```



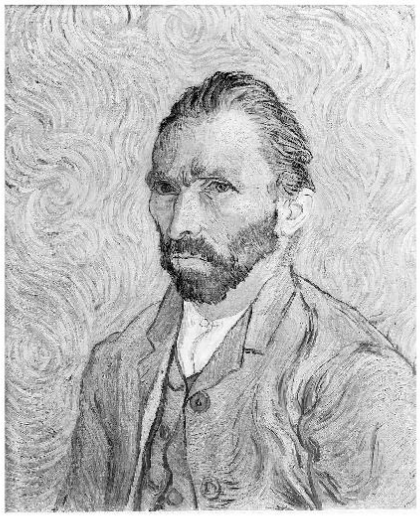
```
% Separate the image into three color channels and store each channel
into
% a new image

red_channel = img(:, :, 1); figure, imshow(red_channel);
red_image = zeros(size(img)); red_image(:, :, 1) = red_channel; figure,
imshow(red_image);
      output:
```





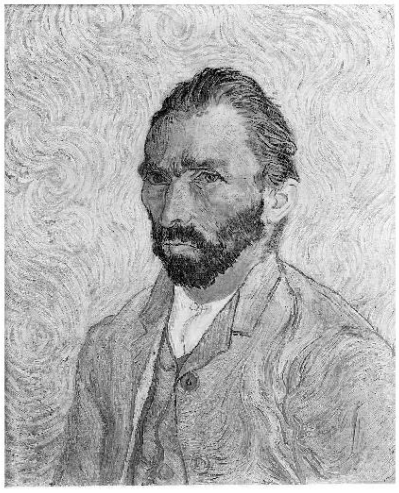
```
%
% Similarly extract green_channel and blue_channel and create
green_image
% and blue_image

% %green_image = ???;
green_channel = img(:, :, 2); figure, imshow(green_channel);
green_image = zeros(size(img)); green_image(:, :, 2) = green_channel;
figure, imshow(green_image);
```

output:



```
% %blue_image = ???;
blue_channel = img(:, :, 3); figure, imshow(blue_channel);
blue_image = zeros(size(img)); blue_image(:, :, 3) = blue_channel;
figure, imshow(blue_image);
```

output:

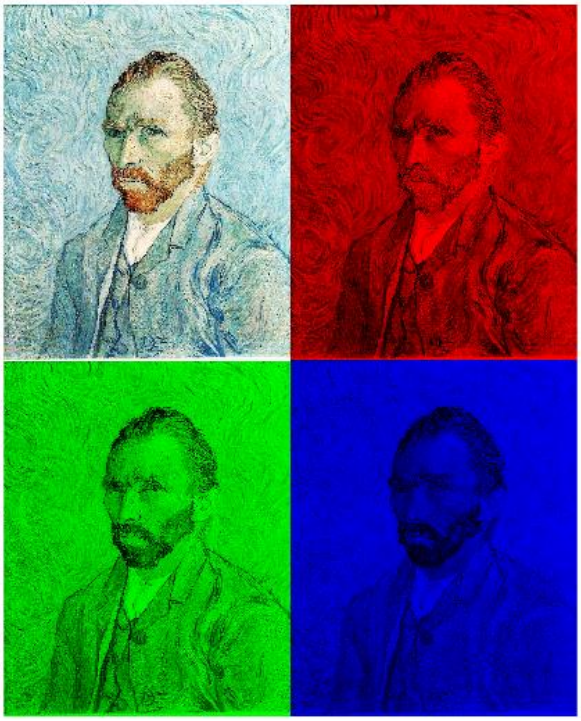


```
% Create a 1 x 4 image collage in the following arrangement
%
% original image | red channel | green channel  | blue channel
collage_1x4 = [img, red_image, green_image, blue_image];
imshow(collage_1x4);
```

output:

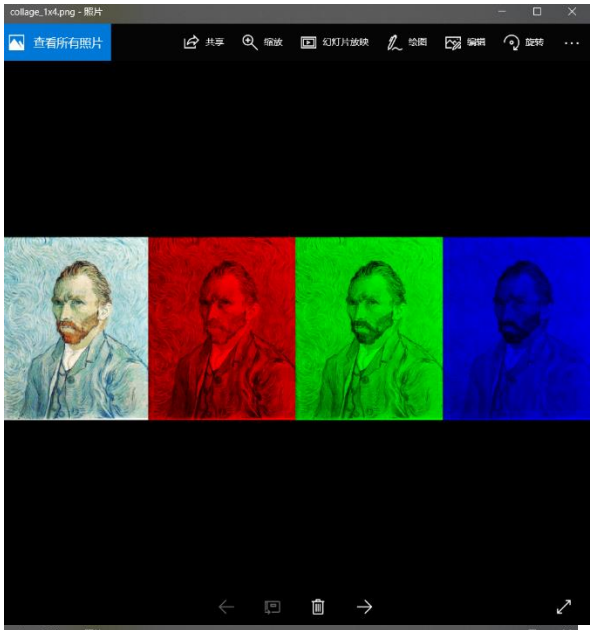
```
% Create a 2 x 2 image collage in the following arrangement
%
% original image | red channel
% green channel  | blue channel

%collage_2x2 = ???
% imshow(collage_2x2);
collage_2x2 = [img, red_image; green_image, blue_image];
imshow(collage_2x2);
```

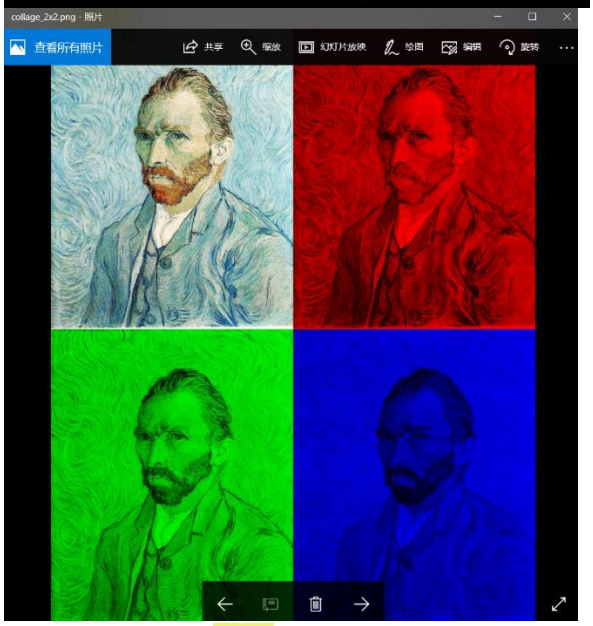
output:

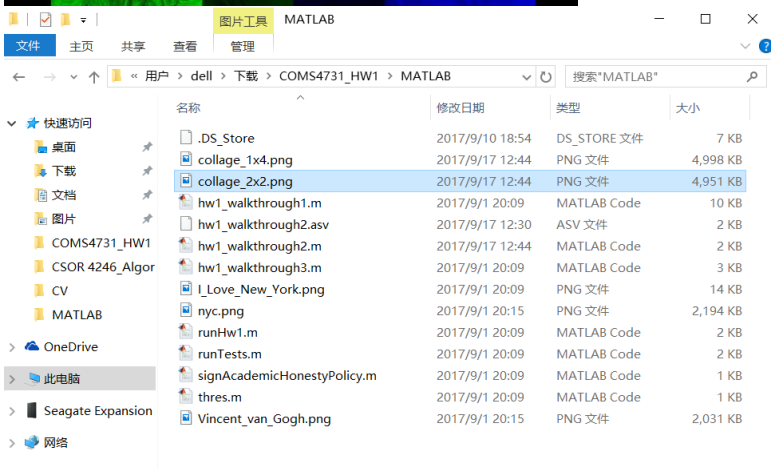


```
% Save the collage as collage.png
% imwrite(???, ???);
imwrite(collage_1x4, 'collage_1x4.png');
imwrite(collage_2x2, 'collage_2x2.png');
```

saved files:


collage_1x4.png - 照片
查看所有照片
共享
缩放
幻灯片放映
绘图
编辑
旋转


collage_2x2.png - 照片
查看所有照片
共享
缩放
幻灯片放映
绘图
编辑
旋转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collage_2x2.png 2017/9/17 12:44 PNG 文件 4,951 KB
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hw1_walkthrough2.asv 2017/9/17 12:30 ASV 文件 2 KB
hw1_walkthrough2.m 2017/9/17 12:44 MATLAB Code 2 KB
hw1_walkthrough3.m 2017/9/1 20:09 MATLAB Code 3 KB
I_Love_New_York.png 2017/9/1 20:09 PNG 文件 14 KB
nyc.png 2017/9/1 20:15 PNG 文件 2,194 KB
runHw1.m 2017/9/1 20:09 MATLAB Code 2 KB
runTests.m 2017/9/1 20:09 MATLAB Code 2 KB
signAcademicHonestyPolicy.m 2017/9/1 20:09 MATLAB Code 1 KB
thres.m 2017/9/1 20:09 MATLAB Code 1 KB
Vincent_van_Gogh.png 2017/9/1 20:15 PNG 文件 2,031 KB

Walkthrough 3

Code and result:

```
% ------------------------------------------------------------------------
----
% Part 3 - Create a I <3 NY image
% ------------------------------------------------------------------------
----

% Load the image "I_Love_New_York.png" into memory
%iheartny_img = imread(???);
iheartny_img = imread('I_Love_New_York.png');

% Display the image
figure(1), imshow(iheartny_img);
```

output:


```
% Convert the color image into a grayscale image
gray_iheartny_img = rgb2gray(iheartny_img);

% Display the image
figure(2), imshow(gray_iheartny_img);
```

output:


```
% Convert the grayscale image into a binary mask using a threshold
value
%threshold = ???;
threshold = 0.5;

binary_mask = im2bw(gray_iheartny_img, threshold);

% Load the image "nyc.png" into memory
%nyc_img = imread(???);
```

```
nyc_img = imread('nyc.png');

% Resize nyc_img so the image height is 500 pixels
%height = size(nyc_img, ???);
height = size(nyc_img, 1);

scale = 500/height;
small_nyc = imresize(nyc_img, scale);

% Resize ILoveNY binary_mask so that its height is 400 pixels
%scale = ???;
scale = 400/500;
resized_mask = imresize(binary_mask, scale);

figure(3);
imshow(resized_mask);
```

output:


```
% Invert the mask
figure(4);
iresized_mask = ~resized_mask; imshow(iresized_mask);
```

output:


```
% Note small_nyc and iresized_mask are of different height and width
size(small_nyc)
```

output:

```
ans = 500        1177           3
```

```
size(iresized_mask)
```

output:

```
ans = 224   240
```

```
% No worries. Let's used the collage technique learned in Part 2 to
make
% iresized_mask with the same height and width as small_nyc
```

```
height_diff = size(small_nyc, 1) - size(iresized_mask, 1);
width_diff = size(small_nyc, 2) - size(iresized_mask, 2);
mask_height = size(iresized_mask, 1); mask_width = size(iresized_mask,
2);
imshow(iresized_mask);
```

output:

```
% Pad left and right
% I made a modifacation here as width_diff is odd number
iresized_mask = [zeros(mask_height, floor(width_diff/2)),...
    iresized_mask, zeros(mask_height, ceil(width_diff/2))];
figure(6);
imshow(iresized_mask);
```

output:

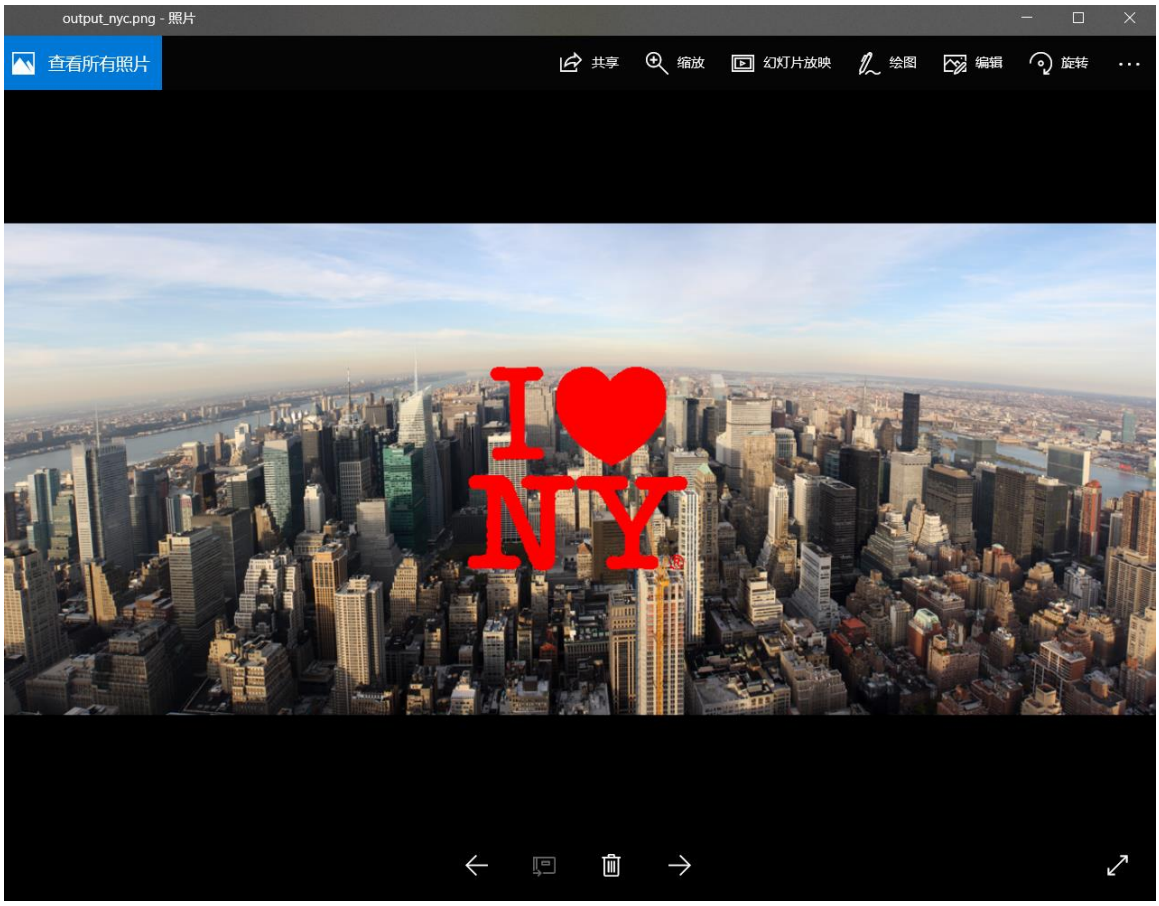
```
% Pad top and bottom
%iresized_mask = ???
iresized_mask = [zeros(floor(height_diff/2), size(iresized_mask,
2));...
    iresized_mask; zeros(ceil(height_diff/2), size(iresized_mask, 2))];
% Cast the mask to logical
iresized_mask = logical(iresized_mask);
figure(7);
imshow(iresized_mask);
```

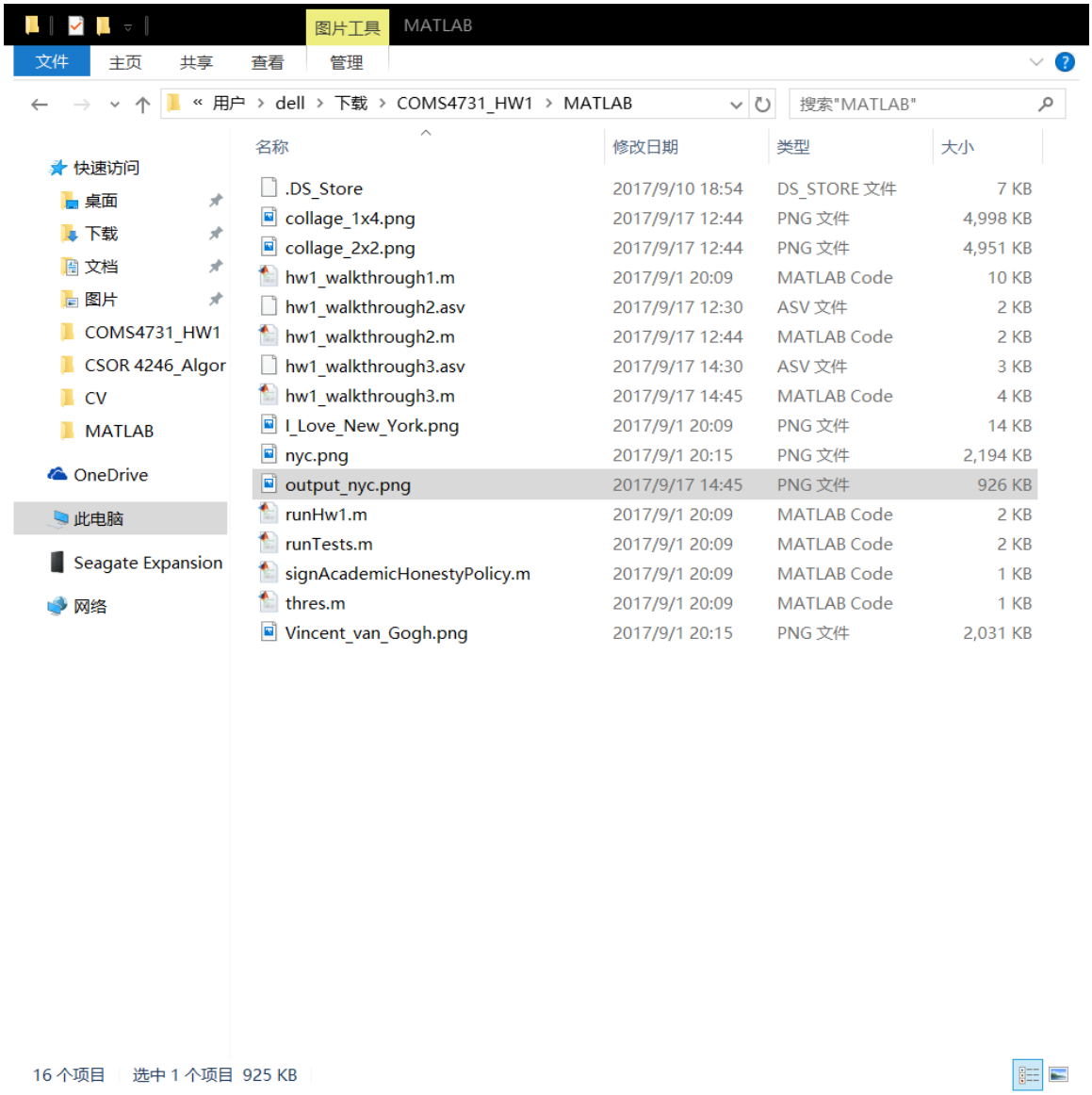
output:


```
% MATLAB has many conveninent functions. The above code can actually be
done
% with single line of MATLAB code.
% The MATLAB documentation is a good place to discover what tools are
% available to you!

% ipadded_mask = padarray(iresized_mask, [height_diff/2 width_diff/2]);

% Now, let's burn the I <3 NY logo into the Manhattan scene
red = [255, 0, 0];
love_small_nyc = small_nyc;

red_channel = love_small_nyc(:, :, 1);
red_channel(iresized_mask) = red(1);
love_small_nyc(:, :, 1) = red_channel;

%???
%love_small_nyc(:, :, 2) = ???;
green_channel = love_small_nyc(:, :, 2);
green_channel(iresized_mask) = red(2);
love_small_nyc(:, :, 2) = green_channel;

%???
%love_small_nyc(:, :, 2) = ???;
blue_channel = love_small_nyc(:, :, 3);
blue_channel(iresized_mask) = red(3);
love_small_nyc(:, :, 3) = blue_channel;

figure(8), imshow(love_small_nyc);
      output:
```


```
% Save the collage as output_nyc.png
%imwrite(???, ???);
imwrite(love_small_nyc, 'output_nyc.png');
```

saved file:

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hw1_walkthrough3.m 2017/9/17 14:45 MATLAB Code 4 KB
I_Love_New_York.png 2017/9/1 20:09 PNG 文件 14 KB
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output_nyc.png 2017/9/17 14:45 PNG 文件 926 KB
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runTests.m 2017/9/1 20:09 MATLAB Code 2 KB
signAcademicHonestyPolicy.m 2017/9/1 20:09 MATLAB Code 1 KB
thres.m 2017/9/1 20:09 MATLAB Code 1 KB
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