Assignment 1

Report

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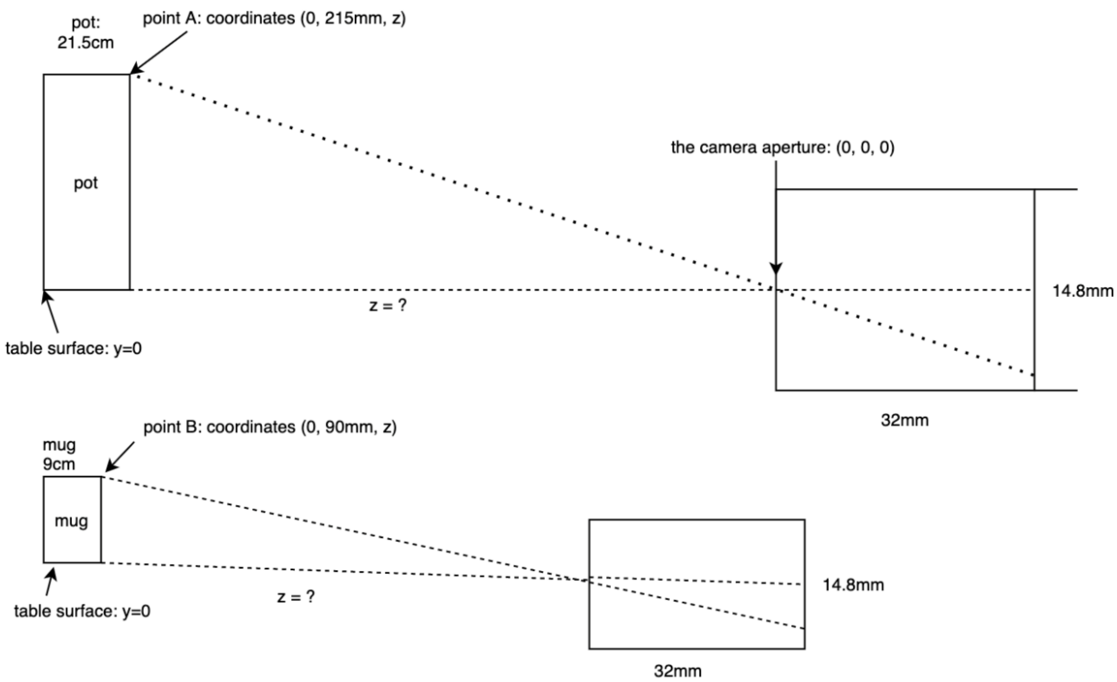
Question 1

According to the pinhole projection model, the given image can be illustrated as Picture 1. Based on the description, it is known that the centre of this picture can be represented as coordinates (0, 0, z), thus, the table surface is corresponding to y-axis whereas both point A and point B are on the x-axis. This can be clearly seen through the visualization using Python code via Jupyter notebook (As shown in picture 2 & 3).

At this point, the real-world coordinates for point A and point B is (0, 215mm, z) and (0, 90mm, z) respectively.



Picture 1: Image represented as pinhole projection model

Picture 2: Cropped image with shape (500, 1500, 3)

Picture 3: Cropped image with shape (1000, 750, 3)

After understanding all the parameters, to obtain the real-world coordinates of both points, the only value that need to be calculated is "z" - the distance from the camera aperture to point A and point B. The pinhole function can be represented as follows:

$$x' = f\frac{x}{z}$$

$$y' = f\frac{y}{z}$$

Where *f* stands for focal length, (x', y') is the point on the image which corresponds to the real-world point (x, y). To find z in this case, the coordinates for both point A and B in the image must be mapped out. After several crop operation, the approximate value of point A and B to the top edge of the picture is 122 and 274 respectively (As shown in Picture 4 & 5). Therefore, the coordinates for both points are A (0, 378); B (0, 226).

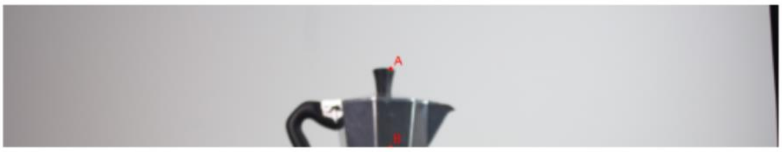
```
crop_4=img[0:122,:,:]
imshow(crop_4)
```

```
(122, 1500, 3)
```

Picture 4: find y-coordinates for point A

```
crop_5=img[0:274,:,:]
imshow(crop_5)
```

```
(274, 1500, 3)
```



Picture 5: find y-coordinates for point B

As the imaging sensor in this camera is 14.8 mm high by 22.2 mm wide and the shape of the whole image is (1000, 1500, 3), the y-coordinate for both points on the imaging sensor can be calculated as follows:

$$\frac{14.8}{1000} = \frac{y_A{}'}{378}$$

$$y_A{}' = \frac{14.8}{1000} \times 378 \ \approx 5.594$$

$$\frac{14.8}{1000} = \frac{y_B{}'}{226}$$

$$y_B{}' = \frac{14.8}{1000} \times 226 \ \approx 3.345$$

After obtained all parameters, the distance z can be calculated by applying the pinhole projection function:

$$z_A = f\frac{y}{y_A'} = 32\ mm \times \frac{215\ mm}{5.594\ mm} = 1229.89\ mm \approx 1230\ mm$$

$$z_B = f\frac{y}{y_B'} = 32\ mm \times \frac{90\ mm}{3.345\ mm} = 860.98\ mm \approx 861\ mm$$

In conclusion, the (x, y, z) coordinates of point A and point B in the world is as follows:

A (0, 215, 1230)

B (0, 90, 861)

Question 2

To create the image with secret message, two image will be used including the message image A and the cover image B. The downloaded original cover image has the shape of (600, 800, 3). Then, with the image has been converted into grayscale, and cropped into a square size with the shape of (600, 600). After this, an empty image with the shape of (600, 600, *3*) has been created and the colour has been set into (255, 255, 255) with a text message shows at the bottom half of it (As shown in Picture 6).

Picture 6

Next step is to apply high/low pass filter to image A and image B respectively in the Fourier domain and the results show in Picture 7 and 8 as follows:

Picture 7: Image A with high pass filter.

Picture 8: Image B with low pass filter

After done the preparation work, the image with secret text can be created by joining both images obtained at last step. With a few times experiment, using high pass filter with spatial frequency thresholds of 50 and low pass filter with spatial frequency thresholds of 40 gives the best result which attracts the least attention from observers. However, this result is solely based on visual inspection (As shown in Picture 9 and Picture 10).

High pass, threshold = 20. *Low pass, threshold = 20.*

High pass, threshold = 30 *Low pass, threshold = 100*

High pass, threshold = 50 *Low pass, threshold = 40*

Picture 9: A comparison of results using different thresholds

Picture 10: Result

In this experiment, the method adopted for a more reliable evaluation is Shannon's entropy [1] of the grayscale image which present the information in one image in a mathematical way [2], thus, the evaluation between two or more images can be done in a quantitatively. After applying the calculation to three blended images, the results show below:

result20_20 entropy: 6.607588690531287

result30_100 entropy: 6.567402608765245

results50_40 entropy: 6.582627566859995

original entropy: 6.878291257152061

Based on the result of the entropy, the blended image using high pass filter with spatial frequency thresholds of 20 and low pass filter with spatial frequency thresholds of 20 gives the best result. As this image has the closest entropy value with the original image.

References:

[1] Gonzalez, R. C., R. E. Woods, and S. L. Eddins. *Digital Image Processing Using* MATLAB. New Jersey, Prentice Hall, 2003, Chapter 11.

[2] Wojcik, T. R., & Krapf, D. (2011). Solid-state nanopore recognition and measurement using Shannon entropy. IEEE Photonics Journal, 3(3), 337-343.