Computer Vision Homework 1 Report

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1. Written Assignment

1.1 Problem 1

a. Assume that the origin is the pinhole and the circular disk's center is in (x_0, y_0, z_0) and the radius is r. The equation of the circular disk is:

$$(x - x_0)^2 + (y - y_0)^2 = r^2, \quad z = z_0 \tag{1}$$

Assume the effective focal length is f. The projection of the circular disk on the image plane is:

$$\frac{x_p}{f} = \frac{x}{z_0}, \quad \frac{y_p}{f} = \frac{y}{z_0} \tag{2}$$

Then the projection of the circular disk on the image plane is:

$$\left(x_p - \frac{x_0 f}{z_0}\right)^2 + \left(y_p - \frac{y_0 f}{z_0}\right)^2 = \left(\frac{rf}{z_0}\right)^2 \tag{3}$$

So the projection of the circular disk on the image plane is a circle with center $(\frac{x_0 f}{z_0}, \frac{y_0 f}{z_0})$ and radius $\frac{rf}{z_0}$.

b.
- For $A = C = D = 0$ and $B = 1$, assume three line directions are $(1, 0, 1)$, $(0, 0, 1)$ and $(-1, 0, 1)$. According to the vanishing point formula:

$$(x_{vp}, y_{vp}) = \left(f\frac{l_x}{l_z}, f\frac{l_y}{l_z}\right) \tag{4}$$

The vanishing point of the three line directions are $(f, 0)$, $(0, 0)$ and $(-f, 0)$.
- For $B = C = D = 0$ and $A = 1$, assume three line are $(0, 1, 1)$, $(0, 0, 1)$ and $(0, -1, 1)$. The vanishing point of the three lines are $(0, f)$, $(0, 0)$ and $(0, -f)$.

c. For the general case, the plane equation is $Ax + By + Cz + D = 0$. We assume that there are anys two different points (x_1, y_1, z_1) and (x_2, y_2, z_2) on the plane. Then

we have:

$$\begin{aligned} Ax_1 + By_1 + Cz_1 + D = 0 \\ Ax_2 + By_2 + Cz_2 + D = 0 \end{aligned} \tag{5}$$

And we know that any line direction can be presented as $(l_x, l_y, l_z) = (x_1 - x_2, y_2 - y_1, z_1 - z_2)$. So we have:

$$\begin{aligned} A(x_1 - x_2) + B(y_2 - y_1) + C(z_1 - z_2) = 0 \\ Al_x + Bl_y + Cl_z = 0 \\ Ax_{vp} + By_{vp} + Cf = 0 \end{aligned} \tag{6}$$

So the vanishing point satisfies the equation $Ax + By + Cf = 0$.

2. Programming Assignment

2.1 Problem 1

a. Choose 128 as the threshold. The result is shown in Figure 2..1b and 2..1f.

b. Each connected region is labeled with a different color. The result is shown in Figure 2..1c and 2..1g.

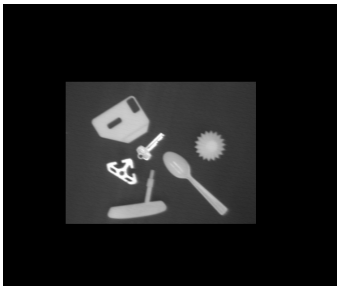
c. Use the formulas that we have learned in the class. The result is shown in Figure 2..1d and 2..1h.

2.2 Problem 2

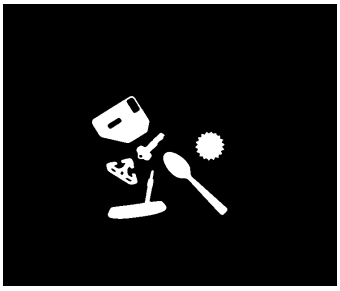
a. Choose $[[-1, 0, 1], [-2, 0, 2], [-1, 0, 1]]$ and $[[1, 2, 1], [0, 0, 0], [-1, -2, -1]]$ as kernels of Sobel edge detector. The result is shown in Figure 2..2a.

b. Choose 128 as the edge threshold and $[20, 21, \cdots, 30, 40]$ as radius values. The result of get edges is shown in Figure 2..2b.

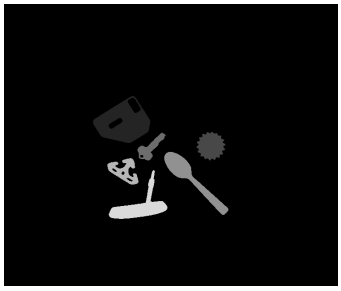
c. Choose 80 as the Hough vote threshold. Final circle edges are shown in Figure 2..2c and the attributes of the circle edges are shown in Figure 2..2d.



(a) many_objects_1_gray



(b) many_objects_1_binary



(c) many_objects_1_labeled

```
PS D:\Computer Vision\CV_HW1> python p1_object_attributes.py many_objects_1 128
[{'position': {'x': 265.97616566814276, 'y': 364.13401927585306}, 'orientation': -0.08042727460237048, 'roundedness': 0.52171968892113
34}, {'position': {'x': 461.6430812129662, 'y': 312.7504356918787}, 'orientation': -1.2635628997735306, 'roundedness': 0.9902664427338
179}, {'position': {'x': 326.0154385964912, 'y': 308.2947368421053}, 'orientation': -0.778838508705404, 'roundedness': 0.1331947199392
6818}, {'position': {'x': 417.71620665251237, 'y': 240.2918141071072}, 'orientation': 0.7760238443266907, 'roundedness': 0.0244216098
26590793}, {'position': {'x': 268.308282208589, 'y': 256.85327198364007}, 'orientation': 0.5388371734983287, 'roundedness': 0.48607322
06012447}, {'position': {'x': 303.571394686907, 'y': 177.2730075901328}, 'orientation': -0.40520199272654894, 'roundedness': 0.2702711
8415863594}]
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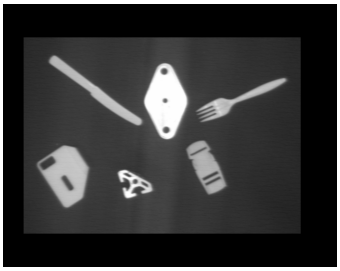
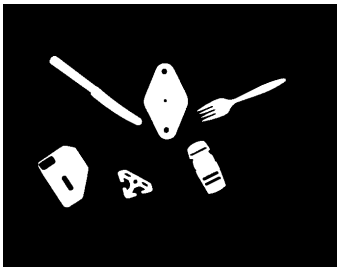
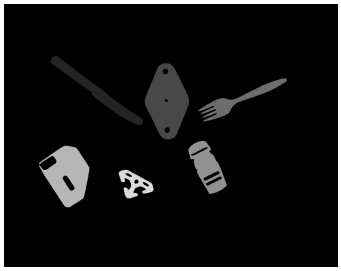
(d) many_objects_1_attribute



(e) many_objects_2_gray



(f) many_objects_2_binary

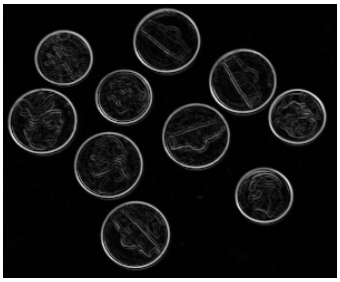


(g) many_objects_2_labeled

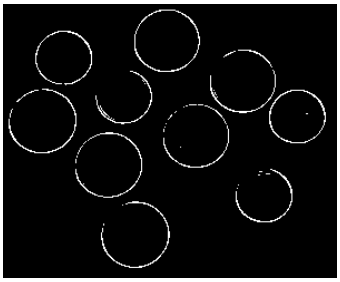
```
PS D:\Computer Vision\CV_HW1> python p1_object_attributes.py many_objects_2 128
[{'position': {'x': 188.3515625, 'y': 356.90033143939394}, 'orientation': 0.6431420831724858, 'roundedness': 0.007633528961638961}, {'
position': {'x': 331.9617982504706, 'y': 337.21769460746316}, 'orientation': 1.5309195723290276, 'roundedness': 0.3072674024989233},
{'position': {'x': 475.3399815894446, 'y': 338.96716784289663}, 'orientation': -0.40324741948779724, 'roundedness': 0.0208554512859631
7}, {'position': {'x': 413.6556685685934, 'y': 203.95137682957085}, 'orientation': 1.1179094173122177, 'roundedness': 0.17394416151886
224}, {'position': {'x': 130.16157675232074, 'y': 187.15229382483517}, 'orientation': 1.448381343829274, 'roundedness': 0.50787669439
74351}, {'position': {'x': 265.9671412924425, 'y': 168.64622124863092}, 'orientation': 0.4929693290413842, 'roundedness': 0.4809122478
5679204}]
```

(h) many_objects_2_attribute

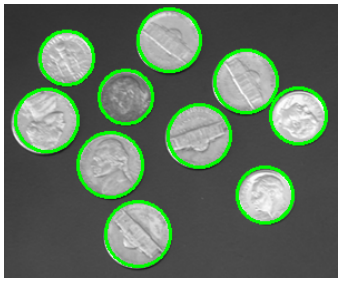
图 2..1 Results of Problem 1



(a) coins_edges_sobel



(b) coins_edges



(c) coins_circles

```
PS D:\Computer Vision\CV_HW1> python .\p2_hough_circles.py coins 128 20 40 80
[(24, 48, 56), (24, 83, 109), (25, 100, 264), (25, 171, 234), (28, 32, 148), (28, 69, 217), (28, 104, 38), (28, 118, 175), (29, 144, 9
5), (29, 206, 120)]
```

(d) coins_attribute

图 2..2 Results of Problem 2