

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:

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

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

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

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

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

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

- 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:

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

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 any 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 $(l_x, l_y, l_z) = (x_1 - x_2, y_1 - y_2, z_1 - z_2)$. So we have:

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

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

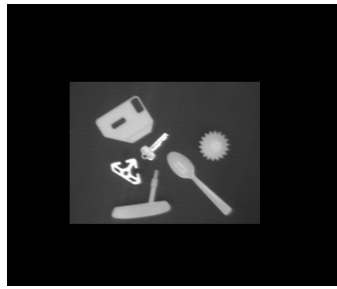
2. Programming Assignment

2.1 Problem 1

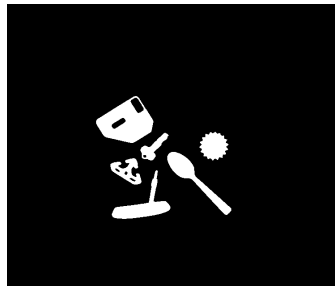
- Choose 128 as the threshold. The result is shown in Figure 2..1b and 2..1f.
- Each connected region is labeled with a different color. The result is shown in Figure 2..1c and 2..1g.
- Use the formulas that we have learned in the class. The result is shown in Figure 2..1d and 2..1h.

2.2 Problem 2

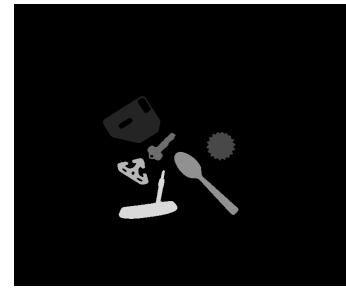
- Choose $[[-1, 0, 1], [-2, 0, 2], [-1, 0, 1]]$ and $[[1, 2, 1], [0, 0, 0], [-1, -2, -1]]$ as kernels of Sobel edge detector. The result is shown in Figure 2..2a.
- Choose 128 as the edge threshold and $[20, 21, \dots, 30, 40]$ as radius values. The result of get edges is shown in Figure 2..2b.
- Choose 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



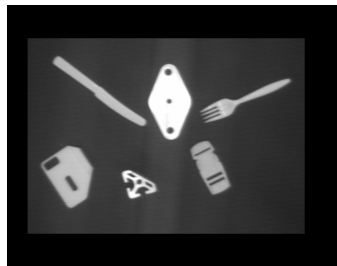
(b) many_objects_1_binary



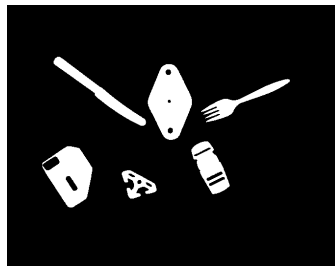
(c) many_objects_1_labeled

```
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': 240.29181410710072, '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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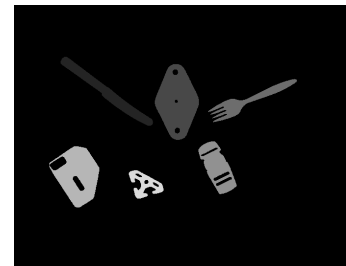
(d) many_objects_1_attribute



(e) many_objects_2_gray



(f) many_objects_2_binary

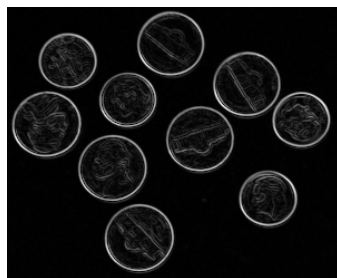


(g) many_objects_2_labeled

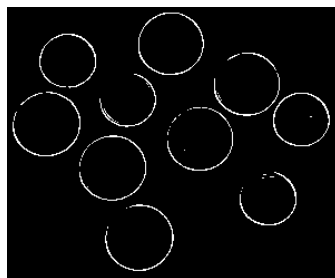
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PS D:\Computer Vision\CV_HW1> python p1_object_attributes.py many_objects_2 128
[{'position': {'x': 188.3515625, 'y': 356.90033143939394, 'orientation': 0.6431420831724858, 'roundedness': 0.007633528961638961}, {'
position': {'x': 331.9617982504706, 'y': 337.21769460746316, 'orientation': 1.5309195723290276, 'roundedness': 0.30726744024989233}, {'
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': 1.4483813438029274, 'roundedness': 0.50787669439
74351}, {'position': {'x': 265.9671412924425, 'y': 168.64622124863092, 'orientation': 0.4929693290413842, 'roundedness': 0.4809122478
5679204}]
```

(h) many_objects_2_attribute

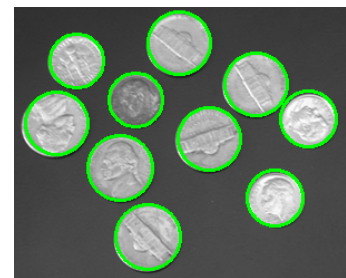
图 2.1 Results of Problem 1



(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