Computer Vision: Homework1

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1 Written Assignment

a. The shape of the image of the disk is a circle. Because the circular disk lies in the plane parallel to the image plane, the circular disk will be vertical to the optical axis. Let' s construct an coordinate with pinhole located at the origin $(0, 0, 0)$ and the disk lies in the plane X-Y and the Z axis goes towards the side where the disk located.

Assume that the center of the disk in the X-Y plane is located at (a, b, o) and the disk has an radius or r. We can have the follow equation:

$$(x-a)^2 + (y-b)^2 = r^2$$

Let' s assume the image of the disk located at another X-Y plane at $Z = i$, and (x', y', i) to represent the image of a point (x, y, o). So based on the pinhole property, the following equations are satisfied:

$$x = -x'\frac{o}{i}$$
$$y = -y'\frac{o}{i}$$

Therefore:

$$\begin{aligned} & (-x'\frac{o}{i} - a)^2 + (-y'\frac{o}{i} - b)^2 = r^2 \\ \Rightarrow\ & (\frac{o}{i})^2[(x + a\frac{i}{o})^2 + (y + b\frac{i}{o})^2] = r^2 \\ \Rightarrow\ & (x-a')^2 + (y-b')^2 = r'^2, \text{ where } a' = -a\frac{i}{o},\ b' = -b\frac{i}{o},\ r' = -r\frac{i}{o} \end{aligned} \tag{1}$$

From the math expression above, we can see that all the image point (x', y', i) for the original point (x, y, o) from the disk will form a new circle.

b.

case 1 $A = C = D = 0,\ B = 1$ We choose $(1, 0, 2)$, $(1, 0, 1)$, and $(5, 0, 4)$ as the three line directions. Their vanishing points are $(\frac{1}{2}f, 0, z_1)$, $(f, 0, z_2)$, and $(\frac{5}{4}f, 0, z_3)$, where $z_1, z_2, z_3 \in R$.

case 2 $B = C = D = 0,\ A = 1$ We choose $(0, 1, 2)$, $(0, 1, 1)$, and $(0, 5, 4)$ as the three line directions. Their vanishing points are $(0, \frac{1}{2}f, z_1)$, $(0, f, z_2)$, and $(0, \frac{5}{4}f, z_3)$, where $z_1, z_2, z_3 \in R$.

c. For a point (x, y, z) on the plane, it satisfies: $y = -\frac{Ax+Cz+D}{B}$. The corresponding image point (x', y', f) should satisfy:

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

$$y' = y\frac{f}{z} = \frac{(Ax + Cz + D)f}{Bz}$$

So, we can have:

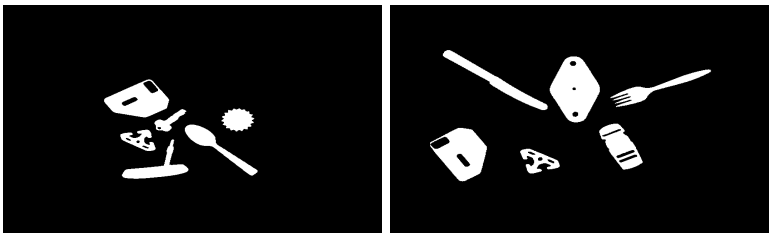
$$\begin{aligned}
& x = x'\frac{z}{f} \\
\Rightarrow\ & x = -\frac{Bzy'}{Af} \cdot \frac{Cz + D}{A} \\
\Leftrightarrow\ & -x'\frac{z}{f} = \frac{Bzy'}{Af} + \frac{Cz}{A} + \frac{D}{A} \\
\Leftrightarrow\ & Ax' = -By' - Cf + \frac{Df}{z},\ \text{where } z \to \infty \\
\Rightarrow\ & Ax' = -by' - Cf \\
\Rightarrow\ & Ax' + By' + Cf = 0
\end{aligned} \tag{2}$$

So the vanish points are located on $AX + BY + Cf = 0$.

2 Programming Assignment

2.1 p1_object_attributes

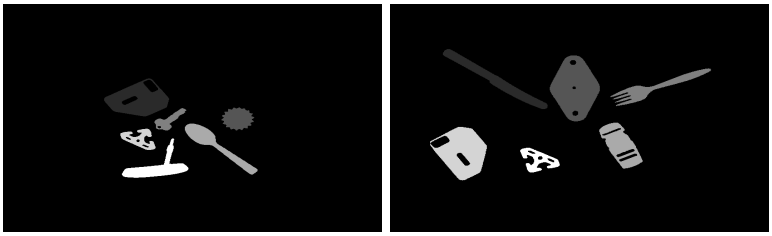
a.



(a) many objects 1 (b) many objects 2

图 1: Binary Images

b. Implement the two-pass version of the algorithm in the notes.



(a) many objects 1 (b) many objects 2

图 2: Labeled Images

c.

```
{'position': {'x': 265.97616566814276, 'y': 364.13401927585306}, 'orientation': 0.08042727460236959, 'roundedness': 0.5217196889211291}
{'position': {'x': 461.6430812129662, 'y': 312.7504356918787}, 'orientation': 1.2635628997731174, 'roundedness': 0.9902664427338298}
{'position': {'x': 326.0154385964912, 'y': 308.29473684210524}, 'orientation': 0.7788385087054034, 'roundedness': 0.1331947199392688}
{'position': {'x': 417.71620665251237, 'y': 240.29181410710072}, 'orientation': -0.7760238443266956, 'roundedness': 0.024421609826594543}
{'position': {'x': 268.30828220858893, 'y': 256.85327198364007}, 'orientation': -0.5388371734983284, 'roundedness': 0.48607322060124447}
{'position': {'x': 303.571394686907, 'y': 177.2730759013283}, 'orientation': 0.40520199272654855, 'roundedness': 0.27027118415863505}
```


(a) many objects 1


```
{'position': {'x': 188.3515625, 'y': 356.90033143939394}, 'orientation': -0.6431420831724862, 'roundedness': 0.0076335289616388195}
{'position': {'x': 331.9617982504706, 'y': 337.21769460746316}, 'orientation': 1.6106730812607657, 'roundedness': 0.3072674402498929}
{'position': {'x': 475.3399815894446, 'y': 338.9671678428966}, 'orientation': 0.40324741948779835, 'roundedness': 0.020855451285964458}
{'position': {'x': 413.6556685685934, 'y': 203.95137682957082}, 'orientation': 2.0236832362775745, 'roundedness': 0.17394416151886066}
{'position': {'x': 130.16157675232074, 'y': 187.1522938248352}, 'orientation': 1.6932113097868653, 'roundedness': 0.5078766943974417}
{'position': {'x': 265.9671412924425, 'y': 168.6462212486309}, 'orientation': -0.4929693290413842, 'roundedness': 0.48091224785679226}
```


(b) many objects 2

图 3: Attribute Lists

2.2 p2_hough_circles

a.

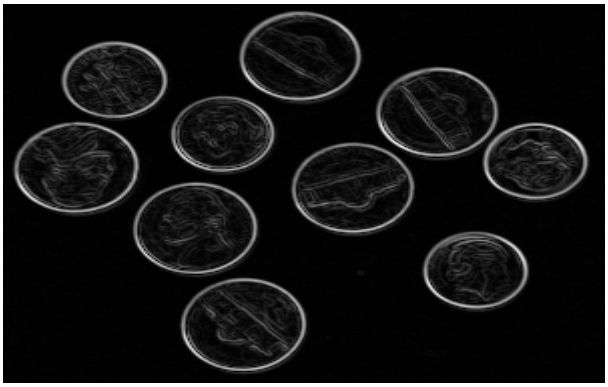


图 4: Origin Image Edges

b.

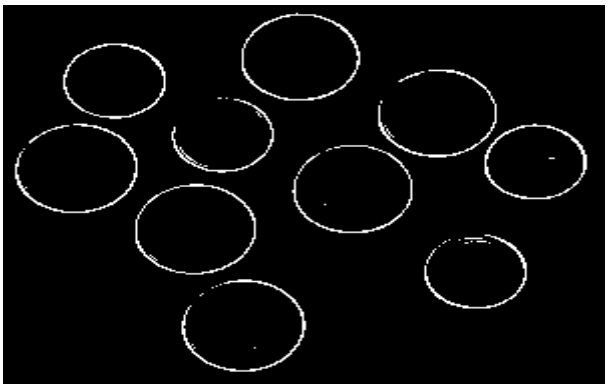


图 5: Image Edges

c.

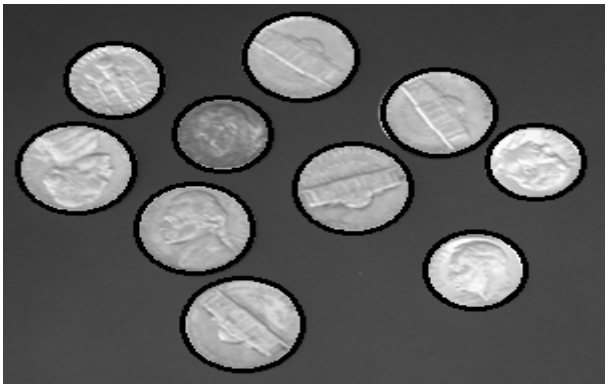


图 6: Image Circles