Written Assignment

a.

Consider the disk center lies on (x, y, z) and the radius is r. And the distance from the pinhole for the image plane is f. Consider the center at the image plane lies on (x', y', f), because of the ratio, we have

$$\frac{z}{f} = \frac{x}{x'} = \frac{y}{y'} \Longrightarrow x' = x\frac{f}{z}, y' = y\frac{f}{z}$$

Since the ratio is the same for every point at the disk, we can get the location for every point on the image plane correspondingly, which means the the shape of the image of the disk is still a circular with $r' = r\frac{f}{z}$.

b.

First, for $A = C = D = 0, B = 1$, choose direction (1,0,1),(3,0,4),(10,0,7), and by the formula

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

The vanishing points of the three direction are respectively $(f, 0), (\frac{3}{4}f, 0), (\frac{10}{7}f, 0)$. All the vanishing points lie in y=0 line.

Second for $B = C = D = 0, A = 1$, choose direction (0,1,1),(0,3,4),(0,10,7). The vanishing points of the three direction are respectively $(0, f), (0, \frac{3}{4}f), (0, \frac{10}{7}f)$. All the vanishing points lie in x=0 line.

c.

Since we can find a value $v = \frac{-D}{A+B+C}$ satisfies $(A + B + C)v + D = 0$, we can ignore D in the following calculations(or we can say that every direction can start from the origin point after shift).

Consider $Al_x + Bl_y + Cl_z = 0$, where the (l_x, l_y, l_z) is the line direction. So the vanishing point is

$$(x_{vp}, y_{vp}) = (f\frac{l_x}{l_z}, f\frac{l_y}{l_z}), A\frac{l_x}{l_z} + B\frac{l_y}{l_z} + C = 0$$

so we have

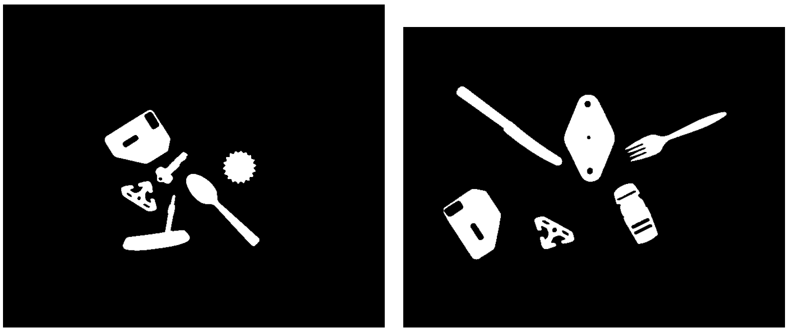
$$Ax_{vp} + By_{vp} + Cf = 0$$

which is the line that the vanishing points of ALL lines lie.

Programming Assignment

1)

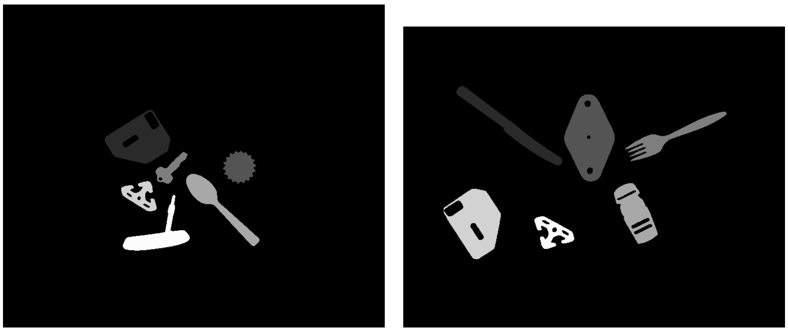
a. The threshold value I use is 128.



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

图 1: binary image

b. Here I implement the two-pass version of the algorithm. And I also maintain a equivalence table to keep the label correctly classified.



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

图 2: labeled image

c. Using the formula in the sides, we can get the attributes for each objects.
For the many objects 1:

- 'x': 265.97616566814276, 'y': 364.13401927585306, 'orientation': 0.08042727460236959, 'roundness': 0.5217196889211291
- 'x': 461.6430812129662, 'y': 312.7504356918787, 'orientation': 1.2635628997731174, 'roundness': 0.9902664427338298
- 'x': 326.0154385964912, 'y': 308.29473684210524, 'orientation': 0.7788385087054034, 'roundness': 0.1331947199392688
- 'x': 417.71620665251237, 'y': 240.29181410710072, 'orientation': -0.7760238443266956, 'roundness': 0.024421609826594543
- 'x': 268.30828220858893, 'y': 256.85327198364007, 'orientation': -0.5388371734983284, 'roundness': 0.48607322060124447
- 'x': 303.571394686907, 'y': 177.27300759013283, 'orientation': 0.40520199272654855, 'roundness': 0.27027118415863505]

For the many objects 2:

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

2)

a. Use 3×3 sobel kernel with convolution to detect edge. The edge magnitude should first normalize by $\frac{M}{M_{max}}$ and then multiply with 255 to recover color.

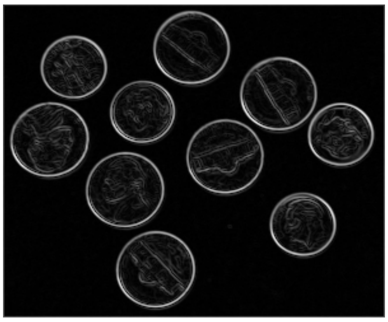
-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

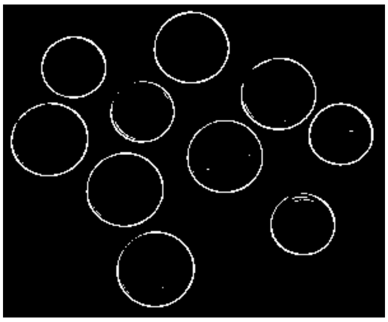
Gy

(a) sobel kernel

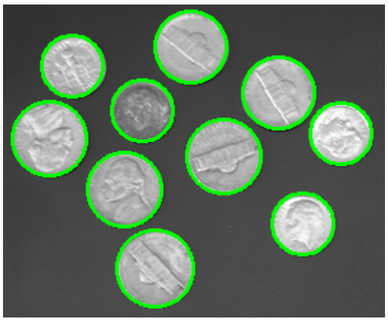


(b) coins edge detect

b. The given edge threshold is between [0,1] so we need to multiply it with 255 and compare with edge magnitude. The edge threshold I choose is 0.45.



(c) coins edge



(d) coins circle

c. The threshold I choose is 200. And since the surrounding points of the possible center of the circle have the very close votes, we can not simply distinguish which one is the true center by simply apply a threshold. Therefore, except the threshold, I choose the maximum votes as the center among the nearby points.

The circle radius and location is at [(24, 48, 54), (24, 83, 109), (24, 101, 265), (24, 172, 235), (28, 33, 147), (28, 69, 216), (29, 105, 36), (29, 119, 173), (29, 145, 95), (30, 207, 119)], which is (radius,x,y).