Computer Vision Homework

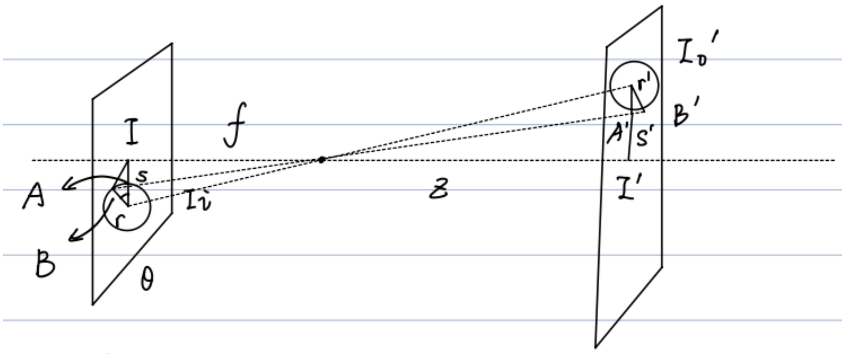
This is the report of the computer vision homework. We have the following parts:

Contents

- Writen assignments.
- Coding reports.

Part 1: Written homework

Question a:



We have that:

$$\frac{S}{f} = \frac{S_0'}{z} \Rightarrow S_0' = S\frac{z}{f}$$

We have that: $r = s - \overline{IA}$ $\quad r' = S_0' - \overline{I'A_0'}$

$$\therefore r' = s\cdot\frac{z}{f} - \overline{IA}\frac{z}{f} = \frac{z}{f} r$$

For any points B, we set $<\overline{I_iB}, \overline{I_iI}> = \theta$.

By the projection properties, $<\overline{I_0'B'}, \overline{I_0'I'}> = \theta$

So $IB = \sqrt{r^2+s^2+2rs\cos\theta}$

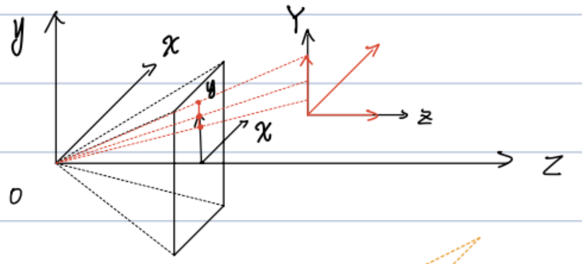
$$\frac{z}{f} IB = \sqrt{(\frac{z}{f})^2(r^2+s^2+2rs\cos\theta)} = \sqrt{r'^2+s'^2+2r's'\cos\theta}$$

So the projection is a circle with radius multiplied by $\frac{z}{f}$.

Question b:

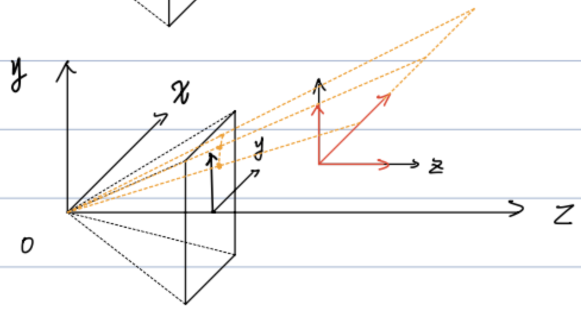
2. First, We have that $X=0$. We have 3 directions

$$\begin{pmatrix}0\\1\\0\end{pmatrix} \begin{pmatrix}0\\1\\1\end{pmatrix} \begin{pmatrix}0\\0\\1\end{pmatrix}$$



for $\begin{pmatrix}0\\1\\0\end{pmatrix}$, We have that

$$v = \begin{pmatrix} f\frac{L_x}{L_z} \\ f\frac{L_y}{L_z} \end{pmatrix}$$ with $L_z = 0$. So No vanishing point.

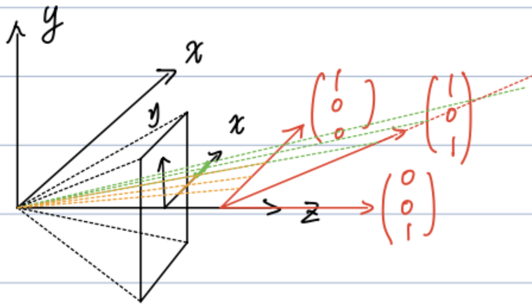


for $\begin{pmatrix}0\\1\\1\end{pmatrix}$, We have that

$$v = \begin{pmatrix} f\frac{L_x}{L_z} \\ f\frac{L_y}{L_z} \end{pmatrix} = \begin{pmatrix}0\\f\end{pmatrix}.$$

for $\begin{pmatrix}0\\0\\1\end{pmatrix}$, $v = \begin{pmatrix}0\\0\end{pmatrix}$.

Second, We have $y=0$



$\begin{pmatrix}1\\0\\0\end{pmatrix} \Rightarrow v =$ No vanishing point

$\begin{pmatrix}1\\0\\1\end{pmatrix} \Rightarrow v = \begin{pmatrix}f\\0\end{pmatrix}$

$\begin{pmatrix}0\\0\\1\end{pmatrix} \Rightarrow v = \begin{pmatrix}0\\0\end{pmatrix}$

Question c:

3. We have that $Ax + By + Cz + D = 0$, So that the perpendicular vector is ratio to (A, B, C).

So all lines comply to

$$Ax + By + Cz = 0$$

$$A\frac{x}{z} + B\frac{y}{z} + C = 0$$

$$Af\frac{x}{z} + Bf\frac{y}{z} + Cf = 0$$

By the Vanishing point

$$v = \left(f\frac{x}{z}, f\frac{y}{z}\right)$$

$$\Rightarrow \underline{A v_x + B v_y + Cf = 0}$$

Δ

Part 2: Coding assignment

`binarize(image)`: I used 128 to get a good binary image. The output is a binary image.

`label(binary_image)`: First we labeled the image by 4 neighbors rule, then we use the **union set** to propagate the labels in the connected components.

`get_attribute(labeled_image)`: We generated the dictionary and has the following outputs:

two_objects.png

```
object 1
label: 1
position: (350.332985, 216.453654)
orientation: -1.259957
roundedness: 0.533632
----------------------
object 2
label: 18
position: (196.316047, 223.382094)
orientation: 0.687546
roundedness: 0.479964
----------------------
```

many_objects_1.png

```
object 1
label: 1
position: (189.351562, 357.900331)
orientation: -0.643142
roundedness: 0.007634
----------------------
object 2
label: 8
position: (332.961798, 338.217695)
orientation: -1.53092
roundedness: 0.307267
----------------------
object 3
label: 86
position: (476.339982, 339.967168)
orientation: 0.403247
roundedness: 0.020855
----------------------
object 4
label: 164
position: (414.655669, 204.951377)
orientation: -1.117909
roundedness: 0.173944
----------------------
```

```
object 5
label: 234
position: (131.161577, 188.152294)
orientation: -1.448381
roundedness: 0.507877
----------------------
object 6
label: 283
position: (266.967141, 169.646221)
orientation: -0.492969
roundedness: 0.480912
----------------------
```

many_objects_2.png

```
object 1
label: 1
position: (266.976166, 365.134019)
orientation: 0.080427
roundedness: 0.52172
----------------------
object 2
label: 87
position: (462.643081, 313.750436)
orientation: 1.263563
roundedness: 0.990266
----------------------
object 3
label: 120
position: (327.015439, 309.294737)
orientation: 0.778839
roundedness: 0.133195
----------------------
object 4
label: 136
position: (418.716207, 241.291814)
orientation: -0.776024
roundedness: 0.024422
----------------------
object 5
label: 152
position: (269.308282, 257.853272)
orientation: -0.538837
roundedness: 0.486073
----------------------
object 6
label: 166
position: (304.571395, 178.273008)
orientation: 0.405202
roundedness: 0.270271
----------------------
```

`detect_edges(gray_image)`:

Before we detect edges, we pass the image through a gaussian filter to constrain its noise.

We use sobel operators as follows:

$$ \begin{align*} G_x=\begin{bmatrix} -1 & 0 & 1\ -2 & 0 & 2\ -1 & 0 & 1 \end{bmatrix},G_y= \begin{bmatrix} 1 & 2 & 1\ 0 & 0 & 0\ -1 & -2 & -1 \end{bmatrix} \end{align*} $$

Then we use a approximate calculator $G=\left|G_x\right|+\left|G_y\right|$.

To approach the official sobel detector we use **reflect padding** instead of **zero padding**.

`hough_circles(edge_image)`: We use the array of radius: [1,2,$\cdots$,41] to do the hough transformation. The hough transform result was in the directory: `./CV_HW1/hough_transform`

`find_circles(image, accum_array, radius_values, hough_thresh)`:

The output was in the `./CV_HW1/output`.