Perspective Projections Project

Background

Consider an image $P(X, Y)$ that lies on the following 3D plane:

$$Z = aX + bY + c, \tag{1}$$

The perspective projection of $P(X, Y)$ is the image $Q(u, v)$. In this project you are asked to compute Q from P, the camera calibration parameters f, u_0, v_0, and the plane parameters a, b, c. It can be shown that the inverse transformation is given by the following equations:

$$X = \frac{c(u - u_0)}{f - a(u - u_0) - b(v - v_0)} = \frac{cx}{f - ax - by}, \quad Y = \frac{c(v - v_0)}{f - a(u - u_0) - b(v - v_0)} = \frac{cy}{f - ax - by}. \tag{2}$$

Part I

The function calculates the 3×3 matrix of a perspective transform so that:

$$\begin{bmatrix} t_i x'_i \\ t_i y'_i \\ t_i \end{bmatrix} = \texttt{map\_matrix} \cdot \begin{bmatrix} x_i \\ y_i \\ 1 \end{bmatrix}$$

where

$$dst(i) = (x'_i, y'_i), src(i) = (x_i, y_i), i = 0, 1, 2, 3$$

Write a program (OpenCV, python) that gets as input P, f; u0; v0, and a; b; c from the command line and displays Q. It should be executed as follows:

```
python3 mynetid1.py image f u0 v0 a b c
```

First, we want to get the Q. We have two ways.

- get u,v from (2)
- simply, change the value in map_matrix below, and project it

In this formula, x' = u, y' = v in Q(u,v) x = X, y = Y in P(X,Y) t = Z in (1)

map_matrix

```
[[c1,c2,c3],

[c4,c5,c6],

[c7,c8,c9]]
```

u = x' = (c1x+c2y+c3)/t v = y' = (c4x+c5y+c6)/t Z = t = (c7x+c8y+c9) c1~c6: camera parameter c1 c5: focus parameter c3,c6: u0,v0

c7 = a, c8 = b, c9 = c

The map_matrix will be set as [[f,0,u0], [0,f,-v0], [a,b,c]]

Part II

Write a program (OpenCV, python) that gets as input the image P and c from the command line. (All other arguments are hardcoded.)

python3 mynetid2.py image c

The two images to be displayed are defined as follows:

Z = aX+bY+c

1. The left side of the image has a smaller Z value than the right side.

We need to create a plan that slop is positive along the axis x.

Set a = 0.001

map_matrix

[[1,0,0],

[0,1,0],

[0.001,0,c]]

2. The bottom side of the image has a smaller Z value than the top side.

We need to create a plan that slop is negative along the axis y.

Set b = -0.001

map_matrix

[[1,0,0],

[0,1,0],

[0,-0.001,c]]