ECE 549 Computer Vision: Homework 3

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1 Single-View Metrology

1.1 Vanishing Points and Vanishing Lines

After determining the parallel lines in images, the vanishing points could be obtained by using cross product of two parallel lines. In my implementation, I use the criteria that the best Vanishing Points minimizes the angles between itself and center points of all the lines to choose VP. Detailed implementation is in *getVP.m*. Figure 1, 2 3 show the detected Vanishing points on X, Y, Z directions respecetively.

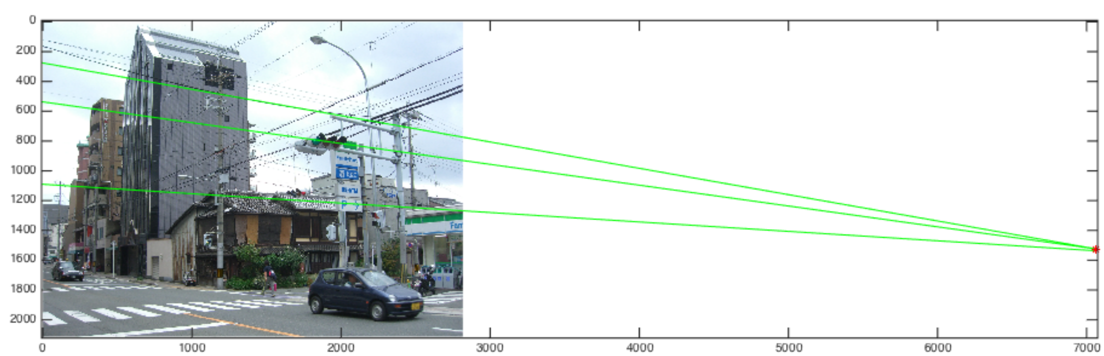

Figure 1: Vanishing Point X: $10^3 * [7.4953, 1.5383, 0.0010]$

Horizon vanishing line could be estimated by taking cross product of VP1 and VP2 (both in horizon directions), which is $10^3 * [1.1216, -6.4439, 0.0010]$.

1.2 Focal Length and Optical Center

Given the intrinsic matrix as

$$K = \begin{pmatrix} f & 0 & u_0 \\ 0 & f & v_0 \\ 0 & 0 & 1 \end{pmatrix}$$

,

and vanishing points $X_i^T X_j = 0$, $\forall i \neq j$, we can use the estimated three vanishing points to estimate the intrinsic matrix K, by taking:

$$X_i^T X_j = p_i^T K^{-T} K^{-1} p_j = 0, \forall i \neq j$$

Figure 2: Vanishing Point Y: $10^3 * [0.0304, 1.5086, 0.0010]$.

, because the rotation matrix $R^T R = I$. Moreover,

$$K^{-T}K^{-1} = \begin{pmatrix} 1/f^2 & 0 & -u_0/f^2 \\ 0 & 1/f^2 & -v_0/f^2 \\ -u_0/f^2 & -v_0/f^2 & \frac{u_0^2+v_0^2}{f^2}+1 \end{pmatrix}$$

.

By involving symbol variables in Matlab command *solve*, we can get the solution: $f = 2248.48$, $(u_0, v_0) = (803.52, 1247.62)$.

1.3 Rotation Matrix

Solving the rotation matrix also relies on the detected three vanishing points. Since

$$\omega \begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = KR \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

,

we use the correspondences between p_1 and $[1, 0, 0]$, p_2 and $[0, 1, 0]$, p_3 and $[0, 0, 1]$ to solve each column of rotation matrix R, as:

$$\omega_1 * p_1 = KR \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} = Kr_1$$

$$\omega_2 * p_2 = KR \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = Kr_2$$

$$\omega_3 * p_3 = KR \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} = Kr_3$$

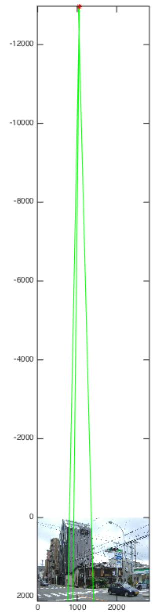

Figure 3: Vanishing Point Z: $10^3 * [1.1216, -6.4439, 0.0010]$

and the constraints that $R * R^T = I$ to solve rotation matrix R, and got:

$$R = \begin{pmatrix} 0.9499 & -0.3123 & -0.0119 \\ 0.0499 & 0.1140 & 0.9922 \\ 0.3085 & 0.9431 & -0.1238 \end{pmatrix}$$

,

1.4 Height Estimation

First Estimate the horizon line: $p_1 = 1.0e{+}03{*}[6.3995, 1.3115, 0.0010]$, $p_2 = 1.0e{+}03{*}[-1.4942, 1.2491, 0.0010]$. And horizon line is got by cross product of p_1 and p_2: $[0, -0.0008, 1.000]$

Figure 4: Horizontal Vanishing Line, estimated by two VPs, $1.0e + 03 * [0.0000, -0.0010, 1.5185]$.