

## 1 Assignment 1 Question 4

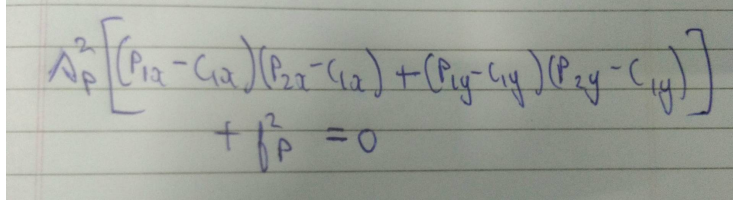
$(p_{1x}, p_{1y}); (p_{2x}, p_{2y}); (p_{3x}, p_{3y})$  and similarly for  $Q$  are in the camera pixel coordinate system. So let us find the direction of the vanishing points by using the focal length and the resolution of both the camera. Assuming  $(c_{1x}, c_{1y})$  and  $(c_{2x}, c_{2y})$  as the origin of the image coordinate system i.e the optical center. The image coordinates are in the  $Z = fp$  and  $Z = fq$  plane respectively. So the direction of  $P_1, P_2, P_3$  will be the coordinate of there vanishing point subtracted from the optical center and multiplied by the resolution. Hence :-

$$\begin{aligned} P_1 &= (s_p(p_{1x}-c_{1x}), s_p(p_{1y}-c_{1y}), f_p). \quad P_2 = (s_p(p_{2x}-c_{1x}), s_p(p_{2y}-c_{1y}), f_p). \\ P_3 &= (s_p(p_{3x}-c_{1x}), s_p(p_{3y}-c_{1y}), f_p). \\ Q_1 &= (s_q(q_{1x}-c_{2x}), s_q(q_{1y}-c_{2y}), f_q). \quad Q_2 = (s_q(q_{2x}-c_{2x}), s_q(q_{2y}-c_{2y}), f_q). \\ Q_3 &= (s_q(q_{3x}-c_{2x}), s_q(q_{3y}-c_{2y}), f_q). \end{aligned}$$

Now these directions of  $P$  and  $Q$  will be related to each other in the same way as the camera orientation. That is  $\mathbf{R}[P_1 \ P_2 \ P_3] = [Q_1 \ Q_2 \ Q_3]$ . From this equation we get the  $\mathbf{R}$  matrix.

Now directions are only connected by rotation or orientation. Translation can't effect the direction of a line. Hence i guess it won't be possible to determine the translation matrix until we are given some other relation between the vanishing points.

Now as the 3 directions are mutually perpendicular, their dot product should be zero. This will give us one equation.



$$s_p^2 [(p_{1x}-c_{1x})(p_{2x}-c_{1x}) + (p_{1y}-c_{1y})(p_{2y}-c_{1y})] + f_p^2 = 0$$

And as per the paper from "Camera calibration using two or three vanishing points Radu Orghidan et.al" the orthocenter of the triangle formed by the 3 vanishing points gives us the optical center of the camera. Using this we will be able to get the optical center. Now from the mutually perpendicular equation, which has both  $s_p$  and  $f_p$  we can get an equation relating them but not exact value.