0.1 Focal Length

A set of parallel lines is parallel to the ray connecting the optical center and their vanishing point. If the vanishing point appears at pixels (x, y) on the image with optical center (x_c, y_c), then the ray is characterized by the homogenous coordinates

$$\begin{bmatrix} x - x_c \\ y - y_c \\ f \end{bmatrix}$$

(assuming aspect ratio of 1). We also know that two rays may be orthogonal in 3D space is the lines parallel to each of them are orthogonal. Thus, let $(x_1, y_1), (x_2, y_2)$ be the vanishing points of two orthogonal set of parallel lines, we have

$$(x_1 - x_c, y_1 - y_c, f) \cdot (x_2 - x_c, y_2 - y_c, f) = 0 \Leftrightarrow$$
$$f^2 = -(x_1 - x_c)(x_2 - x_c) - (y_1 - y_c)(y_2 - y_c)$$

0.2 Height

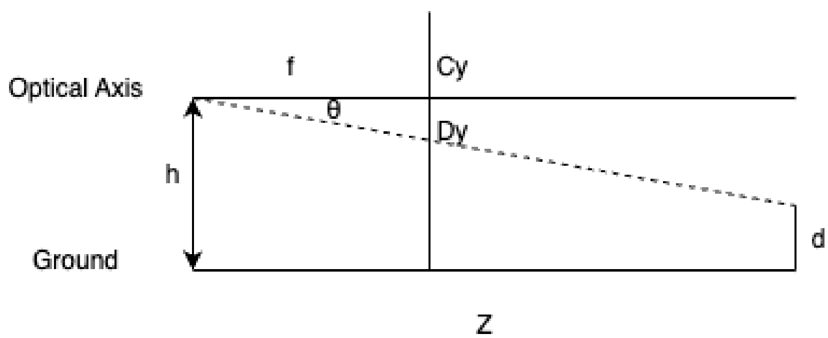

Figure 1: Height Estimation. f the focal length, Z the distance of the object, C_y and D_y the y pixel coordinate of the optical axis and ray connecting the object head, respectively.

Without additional information, the real size of objects in the image is only determined up to scale. However, we can camera height given an object of known height at a known distance, illustrated from the image above. We have with

$$\theta = tan^{-1}(\frac{D_y - C_y}{f})$$

$$h = d - Z \sin\theta$$