

## 3D Reconstruction

### Epipolar Lines

$$p_R^T E p_L = 0 \quad u_L = E p_L p_R^T u_L = x_R u_{L1} + y_R u_{L2} + f u_{L3} = 0 \quad = \text{Epipolar Line}$$

### Pixel Coordinates

$S_x, S_y$  = Width and height of each pixel  $(\hat{x}, \hat{y})$  = Pixel Coordinate  $(\hat{o}_x, \hat{o}_y)$  = Principal Point (Where the principal axis intersects the image plane)

### Fundamental Matrix:

$$p_L = \begin{bmatrix} x_L \\ y_L \\ f \end{bmatrix} = M_L \begin{bmatrix} \hat{x}_L \\ \hat{y}_L \\ f \end{bmatrix} = M_L \hat{p}_L$$

$$p_R^T E p_L = 0 \implies \hat{p}_R^T M_R^T E M_L \hat{p}_L = 0 \implies \hat{p}_R^T F \hat{p}_L = 0 \quad F = M_R^T E M_L = \text{The fundamental matrix}$$

In order to find the actual point P in the scene we can find the intersection of the epipolar lines, however they will usually never intersect so we can pick the closest point on each line and take the average of those points:

$a p_L$  = Closest point to right epipolar line on left line  $b p_R$  = vice versa  $b R^T p_R + T$  is  $b p_R$  wrt left camera  $c(p_L \times R^T p_R + T)$  = distance from left camera to line

Given corresponding points, we know:  $\$ p_L, p_R \$$

Given calibrated views, we know:  $\$ R, T \$$

$$\hat{p} = \frac{(a p_L + b R^T p_R + T)}{2} = \text{Point in the scene at the average of the closest points}$$

# 3-D Reconstruction



$\hookrightarrow$  find  $a, b, c$  s.t.:  $a \mathbf{p}_L - b R^T \mathbf{p}_R - \mathbf{T} - c(\mathbf{p}_L \otimes R^T \mathbf{p}_R) = 0$

Figure 1: Untitled

$$a \begin{bmatrix} \bullet \\ \mathbf{p}_L \\ \bullet \end{bmatrix}_{3 \times 1} - b \begin{bmatrix} R^T \mathbf{p}_R \end{bmatrix}_{3 \times 1} - c \begin{bmatrix} \mathbf{p}_L \otimes R^T \mathbf{p}_R \end{bmatrix}_{3 \times 1} = \begin{bmatrix} \mathbf{T} \end{bmatrix}_{3 \times 1}$$

$$\Rightarrow H \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \mathbf{T} \Rightarrow \begin{bmatrix} a \\ b \\ c \end{bmatrix} = H^{-1} \mathbf{T}$$

Figure 2: Untitled