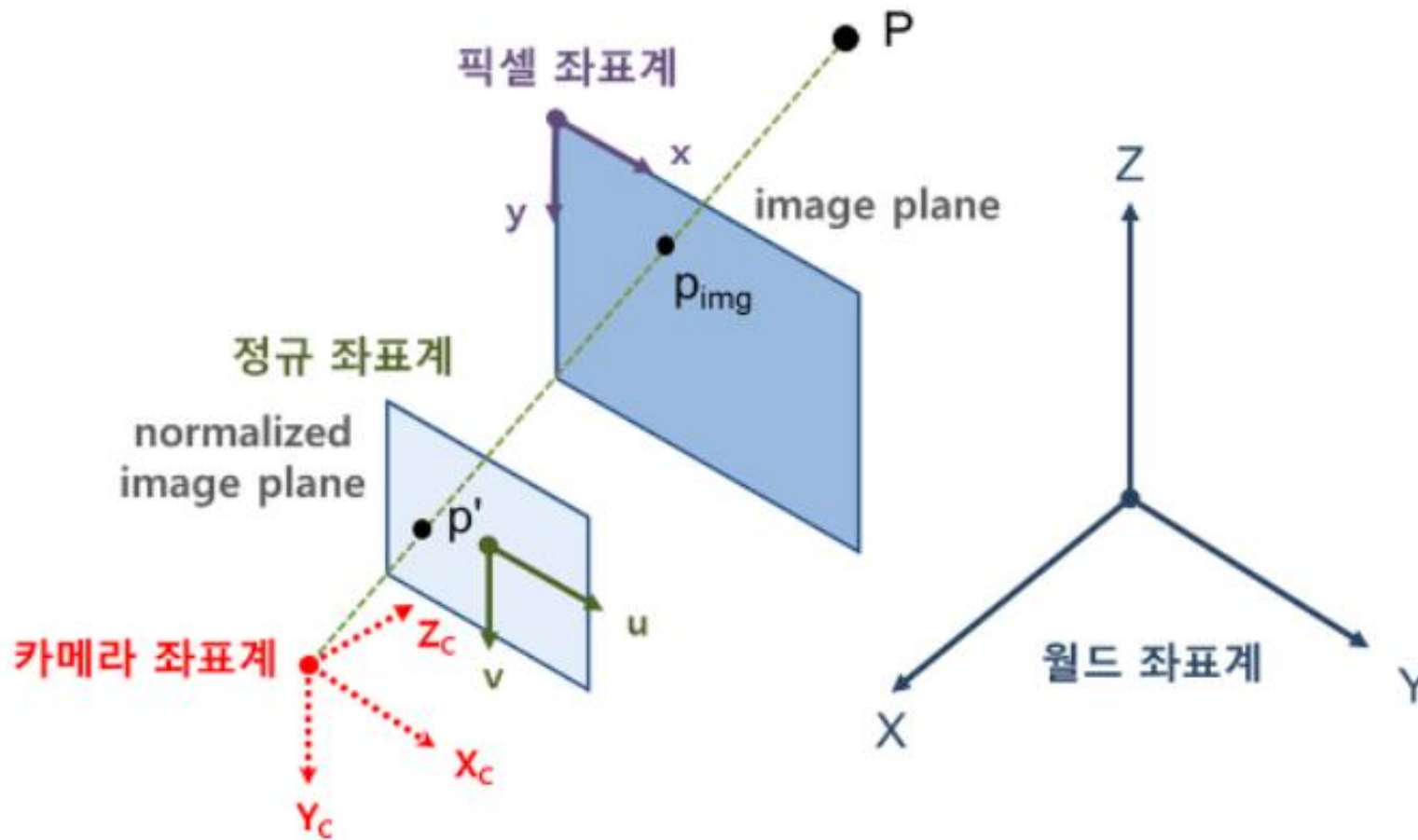


Camera Calibration (2020)RCVWS

신정민

Coordinate System

Coordinate System



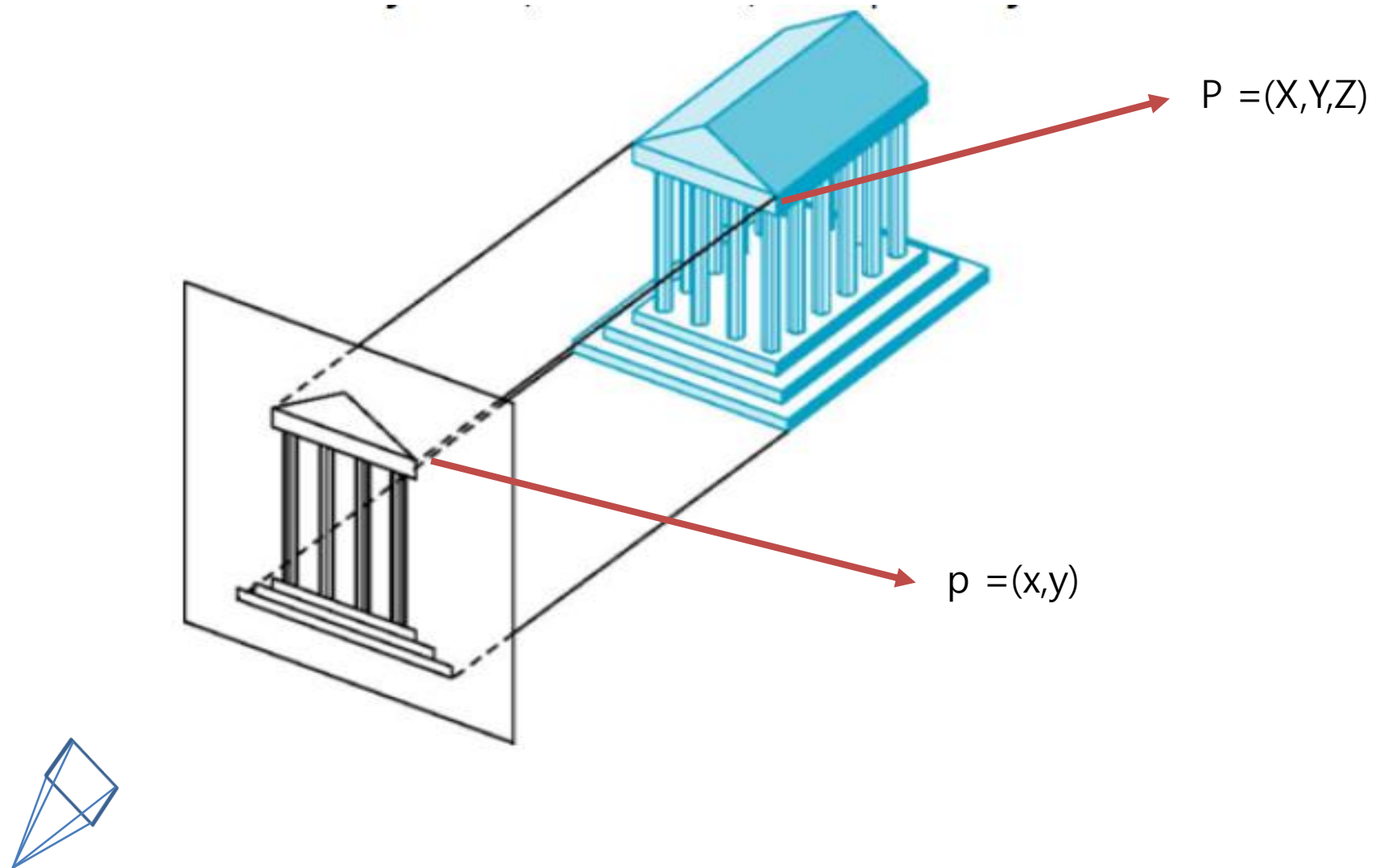
월드 좌표계 : $P = (X, Y, Z)$
 카메라 좌표계 : $P_c = (X_c, Y_c, Z_c)$
 픽셀(영상) 좌표계 : $P_{img} = (x, y)$
 정규 좌표계 : $p' = (u, v)$

$$p_{img} = Kp'$$

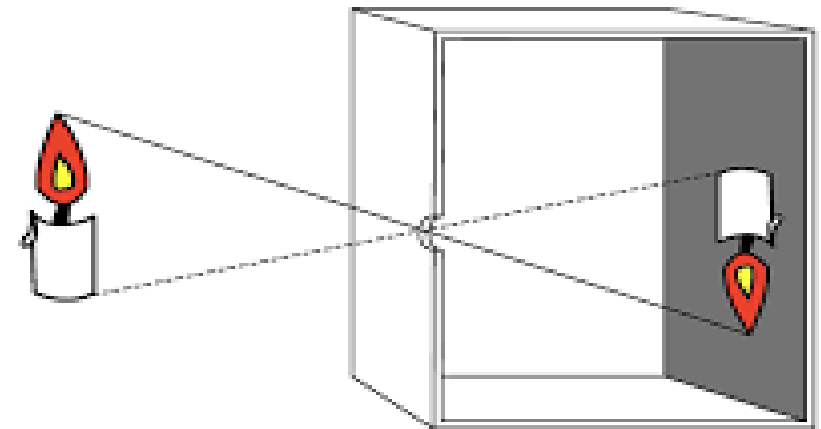
$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u \\ v \\ 1 \end{bmatrix}$$

Camera Calibration

Camera Calibration?



Pinhole Camera

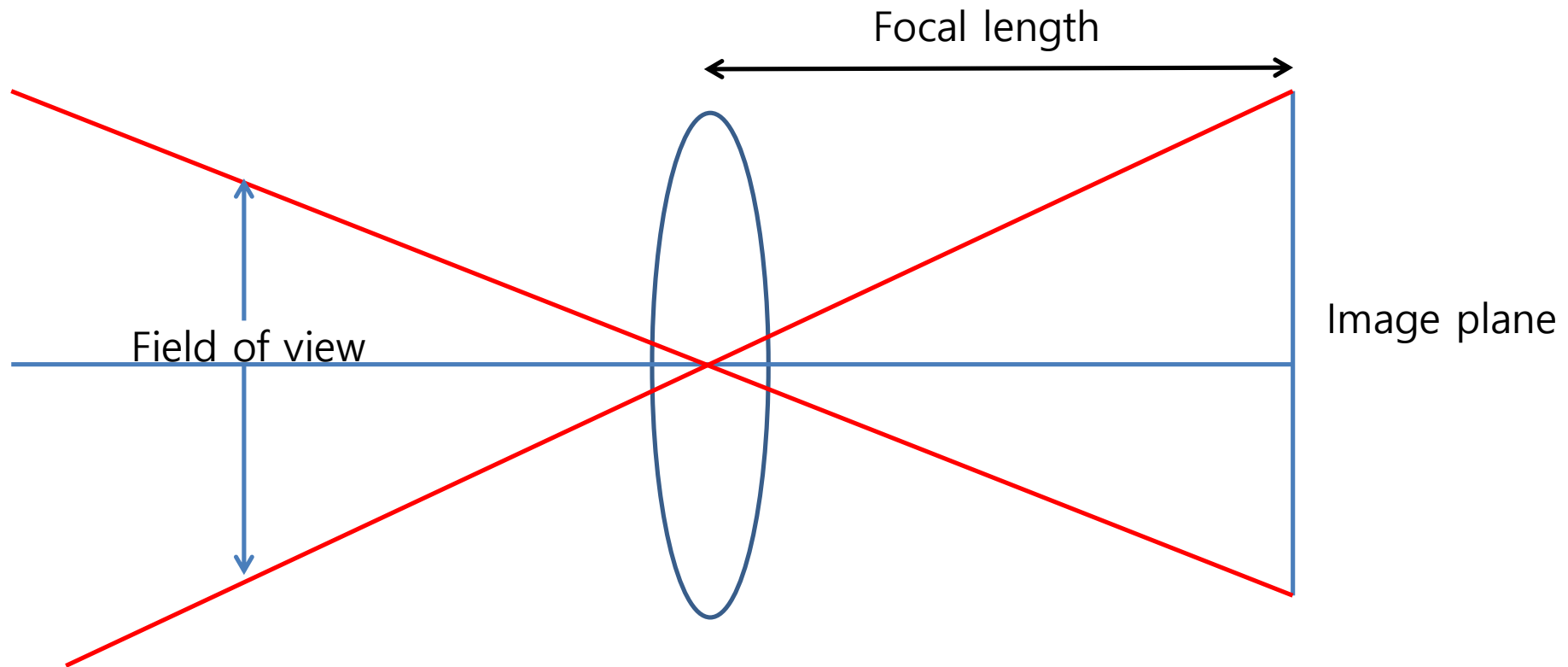


Camera Calibration

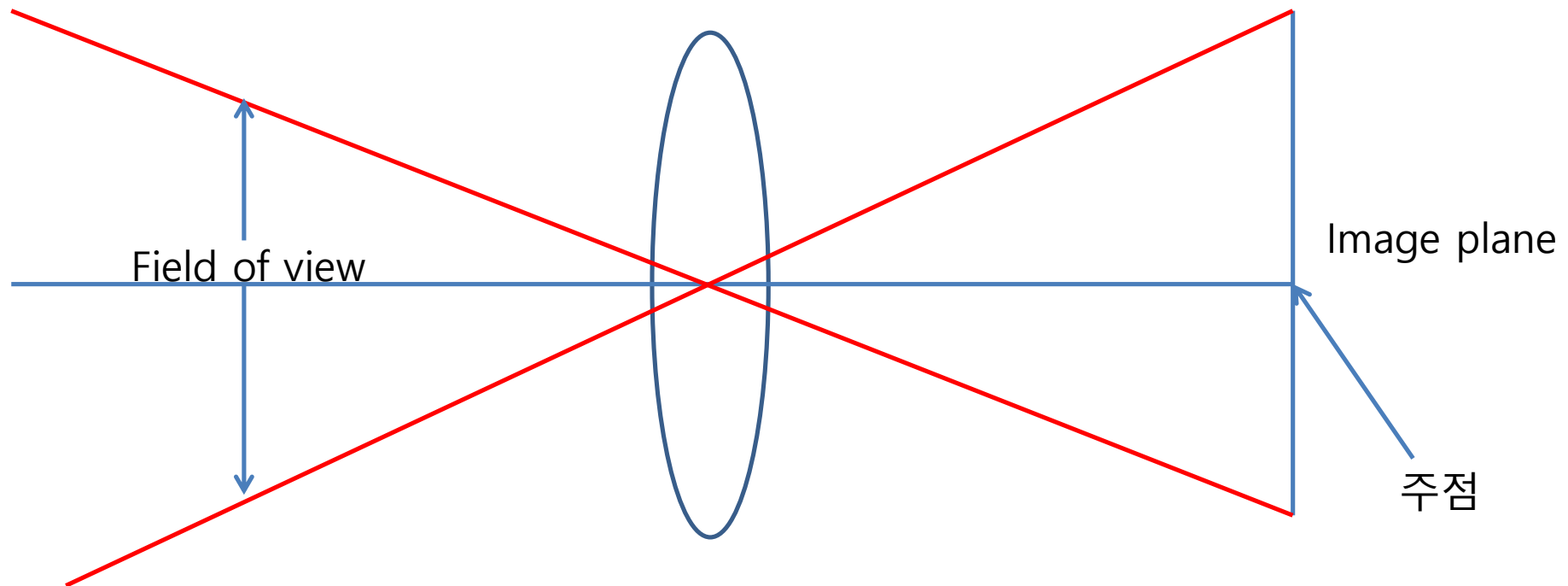
$$s \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & \text{skew_cf}_x & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

$$= A[R | t] \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} \quad (1)$$

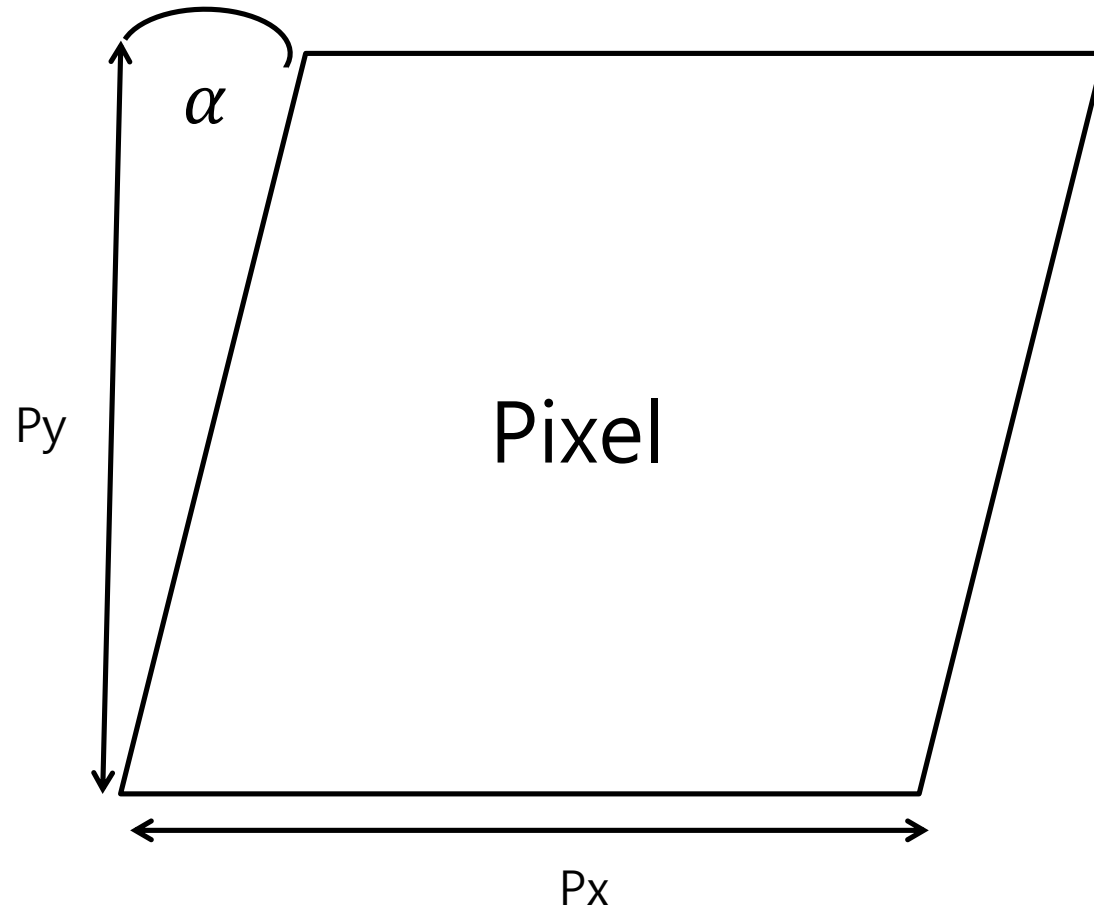
초점거리(Focal length)



주점

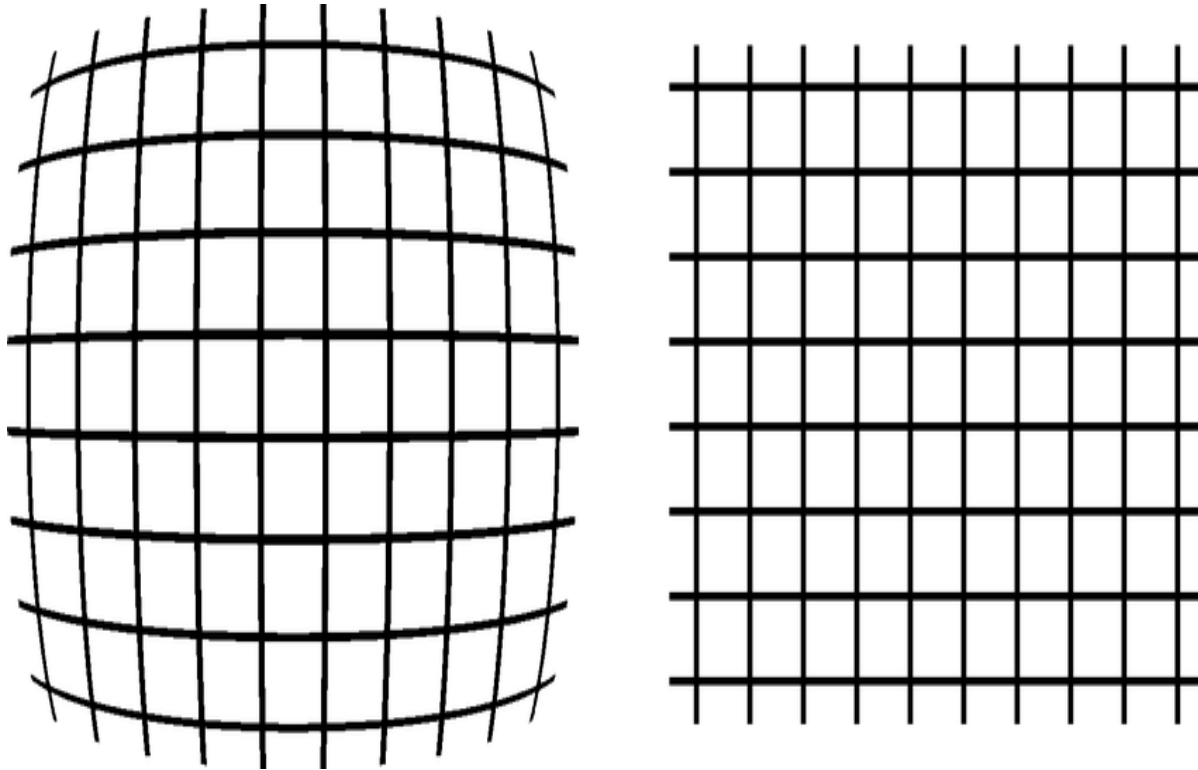


비대칭 계수

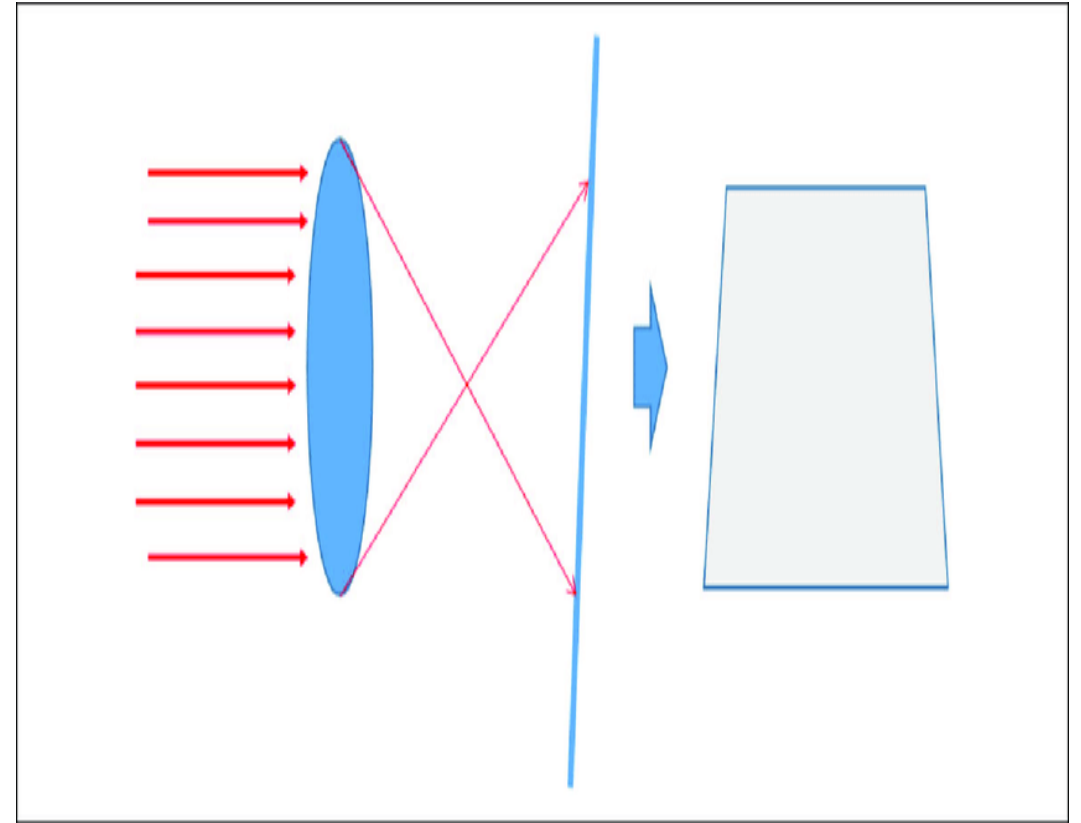


렌즈 왜곡

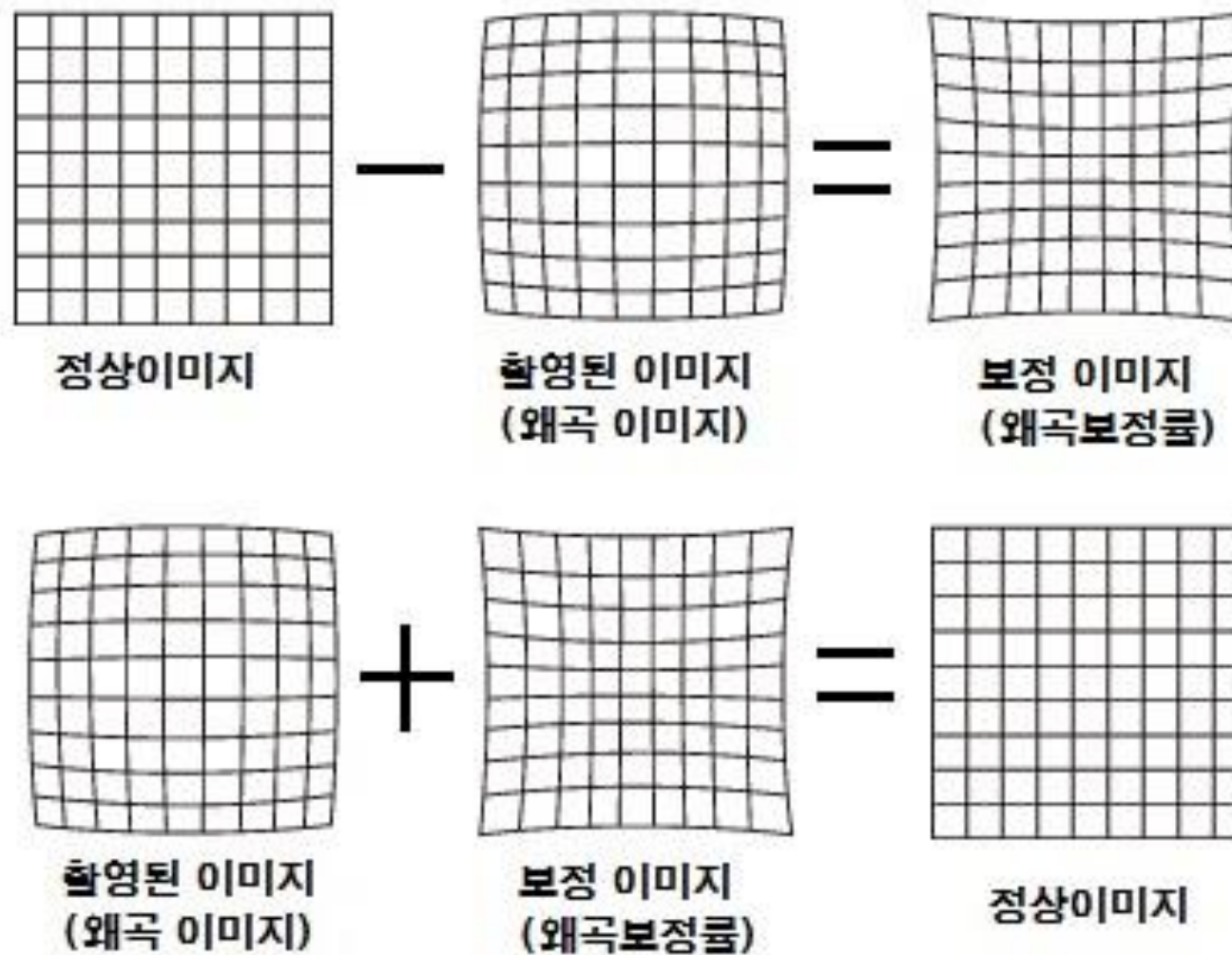
Radial Distortion



Tangential Distortion



왜곡 보정



Stereo Vision

Stereo Vision



Depth Estimation

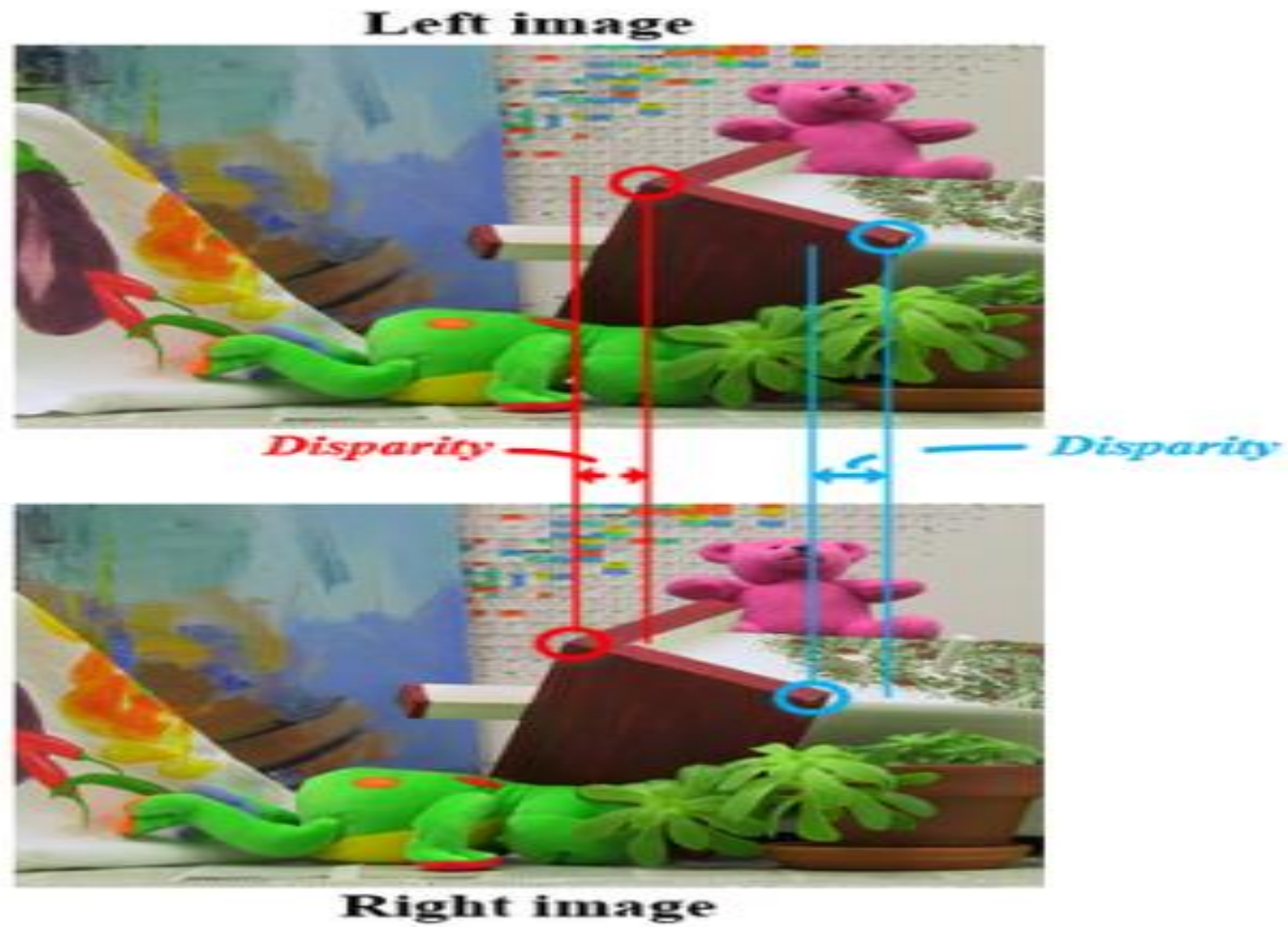


(a) Real-image

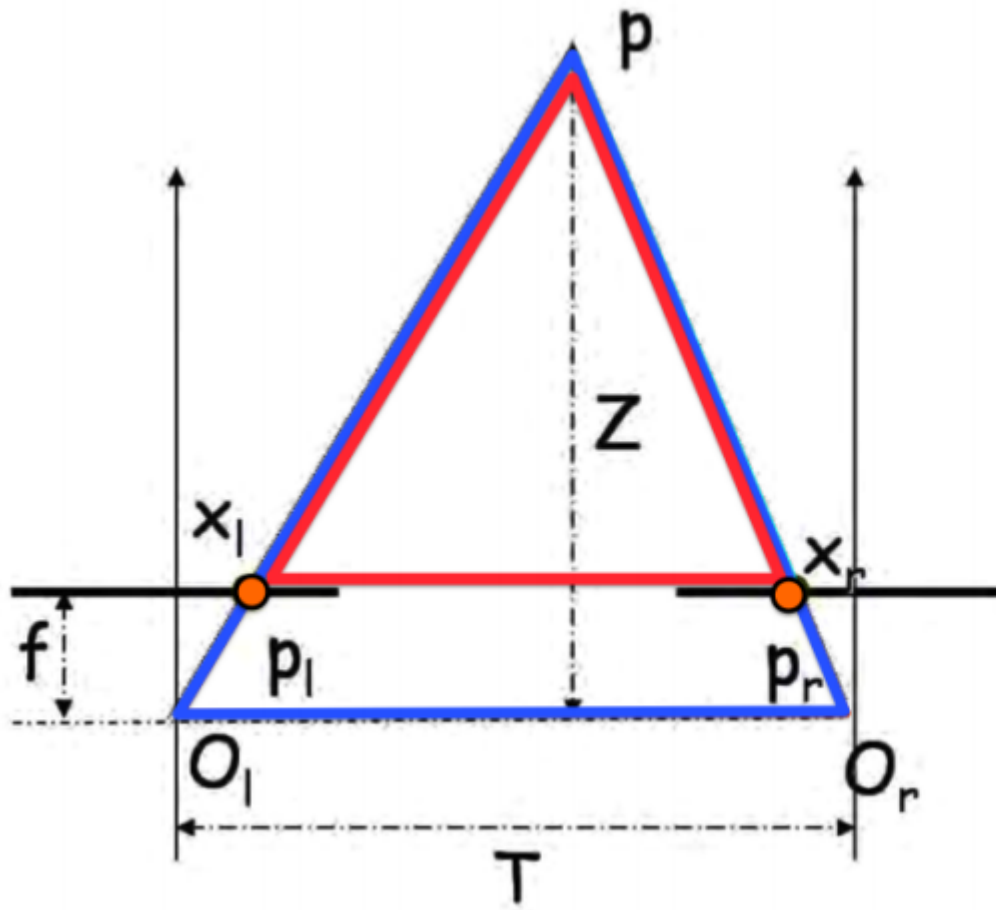


(b) Depth-map

Disparity



삼각측량법



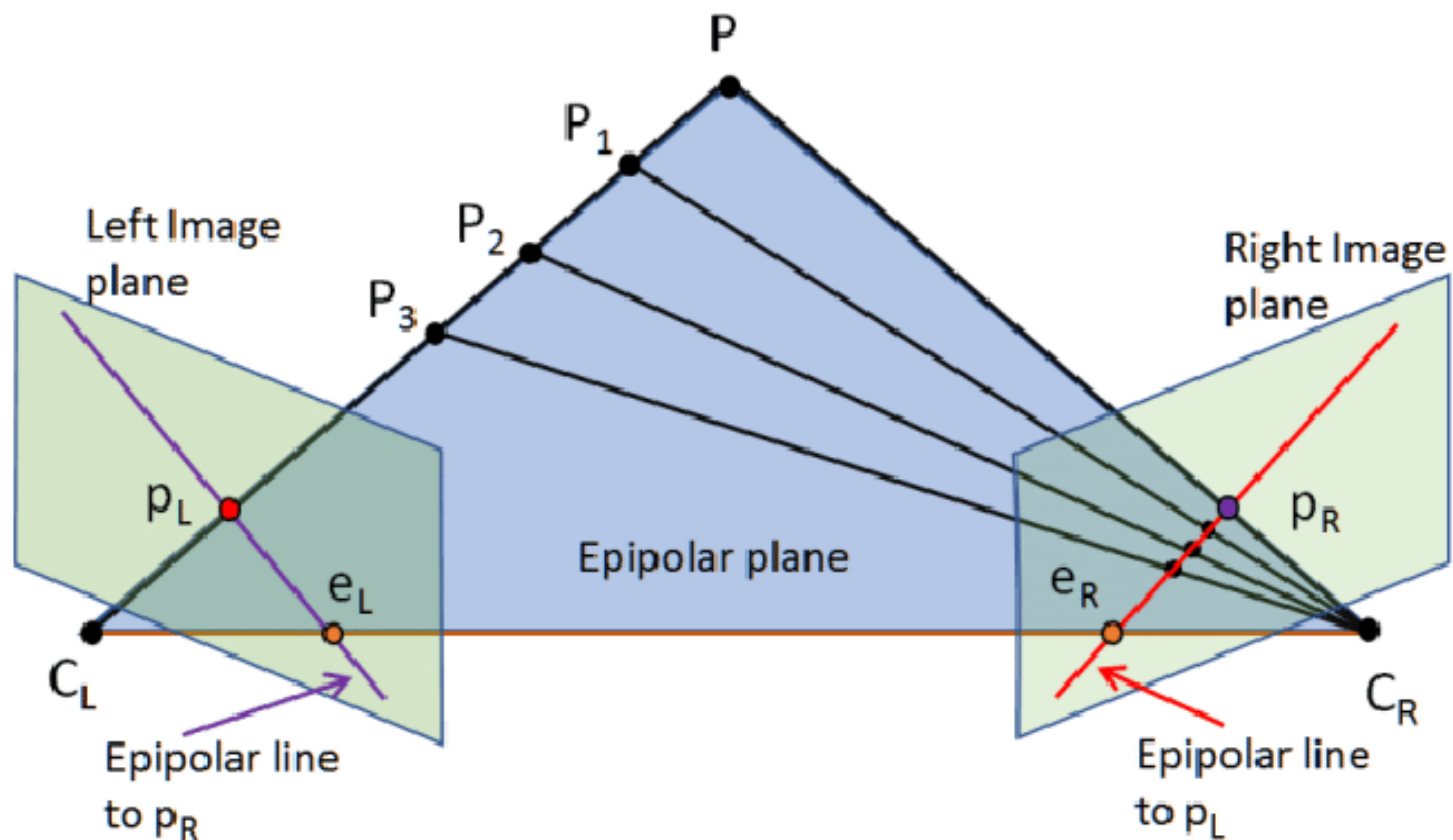
Similar triangles:

$$\frac{T}{Z} = \frac{T + x_r - x_l}{Z - f}$$

$$Z = \frac{f \cdot T}{x_l - x_r}$$

Labels in the diagram:
 - f : focal length
 - T : baseline
 - $x_l - x_r$: disparity

Epipolar Geometry



P : 3차원 물체의 좌표
 C_L, C_R : 좌,우 카메라의 중심
 p_L, p_R : 좌,우 이미지 평면에 P 를 투영시킨 점.
 e_L, e_R : 좌,우 카메라의 epipole

Essential & Fundamental Matrix

$$Ep = l'$$

$$p_{\text{img}} = Kp'$$

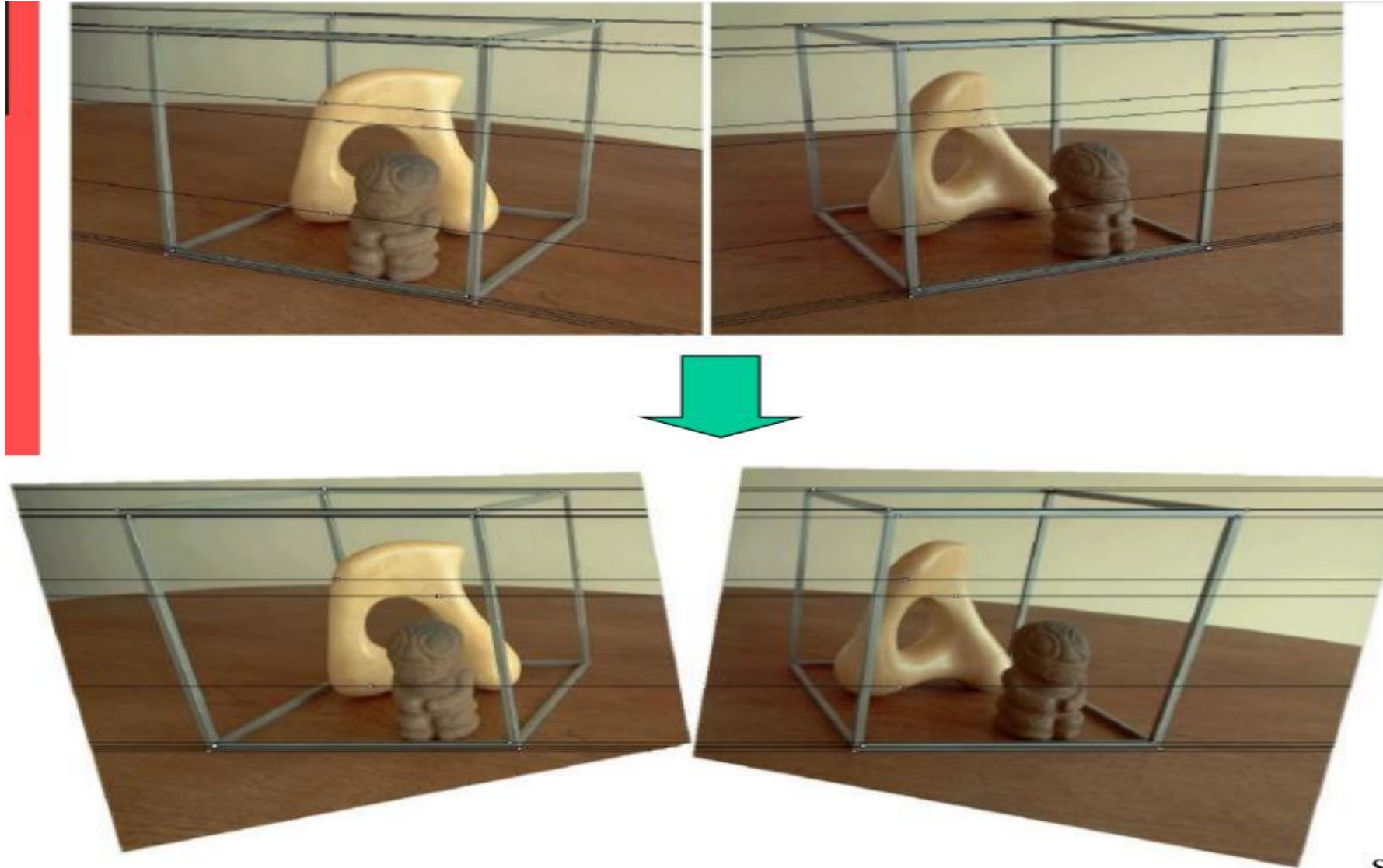
$$p'^T l' = p'^T Ep = 0$$

$$p_{\text{img}}'^T l' = p_{\text{img}}'^T F p_{\text{img}} = 0$$

$$E = K'^T F K$$

$$F = (K'^T)^{-1} E K^{-1}$$

Rectification



S

Stereo Vision

