- Frame change: $\hat{\mathbf{X}}_c = \mathbf{R}(\hat{\mathbf{X}} - \mathbf{C})$ with $\mathbf{X}$ the 3D point in world frame; $\hat{\mathbf{X}}_c$ the 3D point in camera frame, $\mathbf{C}$ camera center in world frame, $\mathbf{R}$ the rotation matrix between camera frame and world frame; $\mathbf{R} = [\mathbf{r}_1, \mathbf{r}_2, \mathbf{r}_3]$ where $\mathbf{r}_1$, $\mathbf{r}_2$ and $\mathbf{r}_3$ the X-axis, Y-axis and Z-axis of world frame represented in camera frame; $\mathbf{R} = \begin{bmatrix} \mathbf{r}_1'^T \\ \mathbf{r}_2'^T \\ \mathbf{r}_3'^T \end{bmatrix}$ where $\mathbf{r}_1'$, $\mathbf{r}_2'$, $\mathbf{r}_3'$ the X-axis, Y-axis and Z-axis of camera frame represented in world frame.

- Projection from 3D to 2D:

$$\begin{aligned} \mathbf{x}_c = & \begin{bmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{bmatrix} \hat{\mathbf{X}}_c = \begin{bmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{bmatrix} \mathbf{R} \left[\mathbf{I} \mid -\mathbf{C} \right] \begin{pmatrix} \hat{\mathbf{X}} \\ 1 \end{pmatrix} \\ = & \begin{bmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{bmatrix} \mathbf{R} \left[\mathbf{I} \mid -\mathbf{C} \right] \mathbf{X} \end{aligned} \tag{1}$$

  with $\mathbf{X} = (X, Y, Z, 1)^T$ the homogeneous coordinates of 3D point $\hat{\mathbf{X}} = (X, Y, Z)^T$, $\mathbf{x}_c$ the homogeneous coordinate of the projected 2D point.

- In pixel coordinate:

$$\begin{aligned} \mathbf{x} = & \begin{bmatrix} m_x & 0 & x_0 \\ 0 & m_y & y_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & -\cot\theta & 0 \\ 0 & \frac{1}{\sin\theta} & 0 \\ 0 & 0 & 1 \end{bmatrix} \mathbf{x}_c \\ = & \begin{bmatrix} m_x & 0 & x_0 \\ 0 & m_y & y_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & -\cot\theta & 0 \\ 0 & \frac{1}{\sin\theta} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{bmatrix} \mathbf{R} \left[\mathbf{I} \mid -\mathbf{C} \right] \mathbf{X} \\ = & \begin{bmatrix} m_x f & -m_x f \cot\theta & x_0 \\ 0 & \frac{m_y f}{\sin\theta} & y_0 \\ 0 & 0 & 1 \end{bmatrix} \mathbf{R} \left[\mathbf{I} \mid -\mathbf{C} \right] \mathbf{X} \\ = & \begin{bmatrix} \alpha_x & s & x_0 \\ 0 & \alpha_y & y_0 \\ 0 & 0 & 1 \end{bmatrix} \mathbf{R}[\mathbf{I} \mid -\mathbf{C}]\mathbf{X} = \mathbf{K}\mathbf{R}[\mathbf{I} \mid -\mathbf{C}]\mathbf{X} = \mathbf{P}\mathbf{X} \end{aligned} \tag{2}$$

  with m_x and m_y the number of pixels per unit length in the skewed x-axis direction and the skewed y-axis direction in the image plane respectively; f (in millimeter) the focal length of camera; x_0 and y_0 the coordinates of the principal point, represented in the skewed image frame in pixels; s the skewness factor which is 0 when the pixel is rectangle; θ the skewness angle between two sides of image CCD plane.

- Calibration matrix:

$$\mathbf{K} = \begin{bmatrix} \alpha_x & s & x_0 \\ 0 & \alpha_y & y_0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} m_x f & -m_x f \cot\theta & x_0 \\ 0 & \frac{m_y f}{\sin\theta} & y_0 \\ 0 & 0 & 1 \end{bmatrix} \tag{3}$$

- Projection matrix: $\mathbf{P} = \mathbf{K}\mathbf{R}\,[\mathbf{I} \mid -\mathbf{C}]$
- Line equation: $ax+by+c=0$ can be written as in homogeneous coordinate $\mathbf{x}^T\mathbf{l} = 0$ with point as $\mathbf{x} = (x, y, 1)^T$ and line as $\mathbf{l} = (a, b, c)^T$.
- The intersection point of two lines $\mathbf{l} = (a, b, c)^T$ and $\mathbf{l}' = (a', b', c')^T$ is $\mathbf{x} = \mathbf{l} \times \mathbf{l}'$ with $\times$ the cross product.
- The line passing through two points $\mathbf{x}$ and $\mathbf{x}'$ has the form $\mathbf{l} = \mathbf{x} \times \mathbf{x}'$.
- Homogeneous points $\mathbf{x} = (x_1, x_2, x_3)^T$ is equivalent to inhomogeneous point $(x_1/x_3, x_2/x_3)^T$ $(x_3 \neq 0)$. Points $\mathbf{x}$ $(x_3 = 0)$ are at infinity. All the points at infinity lie on the line at infinity $\mathbf{l}_\infty = (0, 0, 1)^T$.
- 2D projective transformation (homography) $\mathbf{H}$

$$\begin{pmatrix} x_1' \\ x_2' \\ x_3' \end{pmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} \tag{4}$$

- Epipolar constraint: $\mathbf{x}'^T\mathbf{F}\mathbf{x} = 0$ with $\mathbf{F}$ the fundamental matrix
- Given a point $\mathbf{x}$ in the left image, the corresponding epipolar line in the right image is $\mathbf{l}' = \mathbf{F}\mathbf{x}$. Given a point $\mathbf{x}'$ in the right image, the corresponding epipolar line in the left image is $\mathbf{l} = \mathbf{F}^T\mathbf{x}'$
- Epipoles: $\mathbf{F}\mathbf{e} = \mathbf{0}$ and $\mathbf{F}^T\mathbf{e}' = 0$.