Explain the mathematical basis of how the checkerboard pattern helps in this calibration. Are there some alternate means by which a camera can be calibrated?

The **intrinsic parameters** of the camera, we project the point onto the image plane.

The equations that relate 3D point (X_w, Y_w, Z_w) in world coordinates to its projection (u, v) in the image coordinates are shown below

$$\begin{bmatrix} u' \\ v' \\ z' \end{bmatrix} = \mathbf{P} \begin{bmatrix} X_w \\ Y_w \\ Z_w \\ 1 \end{bmatrix}$$

$$u = \frac{u'}{w'}$$

$$v = \frac{v'}{w'}$$

Where, $\mathbf{P}$ is a 3×4 Projection matrix consisting of two parts — the **intrinsic matrix** (K) that contains the intrinsic parameters and the **extrinsic matrix** ($[\mathbf{R} \mid \mathbf{t}]$) that is combination of 3×3 rotation matrix $\mathbf{R}$ and a 3×1 translation $\mathbf{t}$ vector.

$$\mathbf{P} = \overbrace{\mathbf{K}}^{\text{Intrinsic Matrix}} \times \overbrace{[\mathbf{R} \mid \mathbf{t}]}^{\text{Extrinsic Matrix}}$$

As mentioned in the previous post, the intrinsic matrix K is upper triangular

$$\mathbf{K} = \begin{bmatrix} f_x & \gamma & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}$$