Why To Calibrate? 📏

[Optional Resource]

Some cameras introduce significant distortion to images .Two major kinds of distortion are radial distortion and tangential distortion.To fix these distortions, calibration is important.

Geometric camera calibration, also known as camera resectioning, involves the estimation of a camera's lens and image sensor parameters in images or videos. These parameters are then utilized to rectify lens distortions, gauge object sizes in real-world units, and determine the camera's position within the scene.

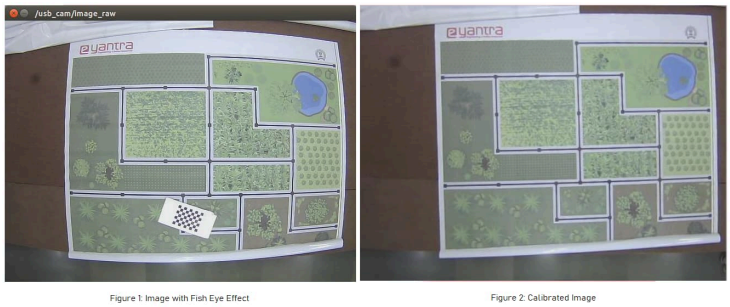


Figure 1: Image with Fish Eye Effect

Figure 2: Calibrated Image

a) Disorted image b) Undisoretd image [CHaneg to your image]

Types of disortions:

- **Radial disortion** : Radial distortion causes straight lines to appear curved. Radial distortion becomes larger the farther points are from the center of the image

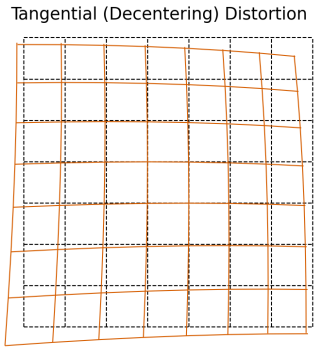
Radial distortion can be represented as follows:

$$x_{\text{distorted}} = x(1 + k_1 r^2 + k_2 r^4 + k_3 r^6)$$

$$y_{\text{distorted}} = y(1 + k_1 r^2 + k_2 r^4 + k_3 r^6)$$

- K_n is the n^{th} radial distortion coefficient;
- $r = \sqrt{(x_{\text{d}} - x_{\text{c}})^2 + (y_{\text{d}} - y_{\text{c}})^2}$, is the Euclidean distance between the distorted image point and the distortion center.

- **Tangential distortion** : Tangential distortion occurs when the image-taking lens is not aligned perfectly parallel to the imaging plane. This misalignment causes some areas in the image to appear nearer than expected.



The amount of tangential distortion can be represented as follows:

$$x_{\text{distorted}} = x + [2p_1xy + p_2(r^2 + 2x^2)]$$

$$y_{\text{distorted}} = y + [p_1(r^2 + 2y^2) + 2p_2xy]$$

In short, five distortion coefficients (k_1, k_2, p_1, p_2, k_3) need to be found.

Distortion Coefficients

Distortion coefficients are represented as:

$$\text{Distortion coefficients} = (k_1, k_2, p_1, p_2, k_3)$$

In addition to this, intrinsic and extrinsic parameters of the camera are required. Intrinsic parameters, specific to a camera, include focal length (f_x, f_y) and optical centers (c_x, c_y). These parameters can be used to create a camera matrix:

The camera matrix is given by

$$\begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}$$

.

Extrinsic parameters correspond to rotation and translation vectors that translate coordinates of a 3D point to a coordinate system.

For stereo applications, these distortions need to be corrected first. To find these parameters, we must provide some sample images of a well defined pattern (e.g. a chess board). We find some specific points of which we already know the relative positions (e.g. square corners in the chess board). We know the coordinates of these points in real world space and we know the coordinates in the image, so we can solve for the distortion coefficients. For better results, we need at least 10 test patterns.

For our calibration process, let's take a simpler route to avoid this complex maths calculations.You can check this route at **Task 4b**.

Reference :

- Opencv
- LearnOpenCV