CSc 8830 Module 2

Camera Calibration and object Measurements.

Mathematical solution

Problem 1: Camera intrinsic Parameters

Goal → Find camera intrinsic Matrix K:

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

Step 1: Chessboard Detection

Capture 20 images of chessboard pattern at varying angles

Detect corner coordinates (u, v) in image Plane

Establish 3D world coordinates (X, Y, Z) at $Z = 0$

Step 2: Linear Estimation

For each image, we use Direct Linear Transformation to compute homography H from 20-30 correspondences.

From the n homographies $\{H_i\}$

$$h_i^T K^{-T} K^{-1} h_i = 0$$

generating linear system $Vb = 0$ where b contains upper triangle of $K^{-T}K^{-1}$

Then we minimize reprojection error using Levenberg-Marquardt:

$$E = \sum_{i,j} \| p_{ij} - project(P_{ij}, K, R_i, t_i) \|^2$$

Problem 2 → Real world object Measurement.

Perspective projection Derivation:

An object of height H_{real} at distance d projects onto the camera sensor with height:

$$h_{sensor} = H_{real} \cdot \frac{f_{mm}}{d}$$

Converting to pixels

$$h_{sensor} = H_{real} \cdot \frac{f_{mm}}{d}$$

$$h_{pixel} = h_{sensor} \cdot \frac{h_{image}}{h_{sensor-total}}$$

$$H_{real} = \frac{h_{pixel} \cdot d}{f_{pixel}}$$

Implementation:

Github repository: https://github.com/arrdel/computer-vision