lec 9 Camera model, Calibiration

① Why we should Calibarate Camera ?

extrinsic, intrisinc parameters of Camera

- extrinsic: Location, orientation
- intrisinc: focal length, size of pexels

CV → Look for 3rd D

Pose estimation

- Given 3D model of object, its image (2D projection)
- Determine (location, orientation) of object such that it will match when project on the image plane

→ (translation, rotation)

② translation Matrix

$$\begin{bmatrix} 1 & 0 & 0 & dx \\ 0 & 1 & 0 & dy \\ 0 & 0 & 1 & dz \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

آخر عمود
dx, y, z, 1

Scaling Matrix

$$\begin{bmatrix} Sx & 0 & 0 & 0 \\ 0 & Sy & 0 & 0 \\ 0 & 0 & Sz & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

diagonal = S_{xyz1}

rotation → around z-axis

$x' = X\cos\theta - Y\sin\theta$

$y' = X\sin\theta + y\cos\theta$

$$\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

⇓

rotation matrices are orthonormal matrices

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$(R^z_\theta)^{-1} = (R^z_\theta)^t$$

$$(R^z_\theta)(R^z_\theta)^T = I$$

③ Euler Angle

rotation around aribitrary axis

if angles are small

$\cos\theta \simeq 1$ $\sin\theta \simeq \theta$

$$R = \begin{bmatrix} 1 & -\alpha & \beta \\ \alpha & 1 & -\gamma \\ -\beta & \gamma & 1 \end{bmatrix}$$

② infront of lens → $\frac{y}{Y} = \frac{f}{Z} \Rightarrow y = \frac{fy}{Z} \quad X = \frac{fX}{Z}$

Prespective Projection

at lens : $\frac{-y}{Y} = \frac{f}{Z} \Rightarrow y = \frac{-fY}{Z} \quad , X = \frac{-fX}{Z}$

orgin at image center : $\frac{-y}{Y} = \frac{f}{Z-f} \Rightarrow y = \frac{Fy}{Z-f} \quad X = \frac{fy}{Z-f}$

$X = \frac{Ch1}{Ch4} \quad y = \frac{Ch2}{Ch4} \quad P = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & -\frac{1}{F} & 1 \end{bmatrix}$

Camera Model

- Camera is at the orgin of the world Co-ordinate
- translated by Some amount (G)
- rotated around Z axis in Counter Clockwise
- rotated again around X axis " " "
- translated by C

⇒ Since we are moving $\boxed{\text{Camera}}$ instead of object we need to use $\boxed{\text{inverse transformation}}$

$$\boxed{Ch = P C R_{-\theta}^{X} R_{-\theta}^{Z} G w_h}$$

Camera matrix

① Select known 3D Points (X,Y,Z) and their Corresponding img point (x,y)

② Solve Camera matrix elements using
→ Least Square fit

homogenous System → n points ∴ equations 2n unknowns

⇒ no-unique Soloution

matrix of rotation → M extrinsic
transition

Camera Parameters

① Extrinsic Parameters
↳ location, orientation of Camera reference frame with respect to known world reference frame

a) 3D-translation vector
b) 3X3 rotation matrix

② intrinsic parameters
Parameters necessary to link pixel co-ordinates of an image point with the corresponding co-ordinates in the camera reference frame

a) Prespective projection (focal length)
b) transformation between camera frame co-ordinates, pixel co-ordinates

Image, Camera Co-ordinate

$x = -(x_{im} - o_x) s_x$

$y = -(y_{im} - o_x) s_y$

$x_{im} = \frac{-x}{s_x} + o_x$

$y_{im} = \frac{-y}{s_y} + o_x$

x_{im}, y_{im} ⇒ image co-ordi

o_x, o_y ⇒ image center

s_x, s_y
↳ effective size of pixels in horizontal, vertical directions

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Using known 3D points, img Co-ordinates

↓

estimate Camera matrix (pseudo inverse method)

Camera Parameters

Extrinsic → translation, rotation

intrinsic → horizontal f_x, vertical f_y

Focal length and

translation of x, y