Lecture 1 :

16 lectures

4 assignments (mandatory) — optional exercises gives extra points to the exam.

6 Q&A - sessions (optional)

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if stuck on an exercise in the Assignment mail Carl

Assignments can be done in groups but it must be done individually.

Latex or by hand.

Assignment 1 : warm up

2: lots of work

3: —— " ——

DON'T START TOO LATE!

4: moderate

The assignment must be finished before April 1!

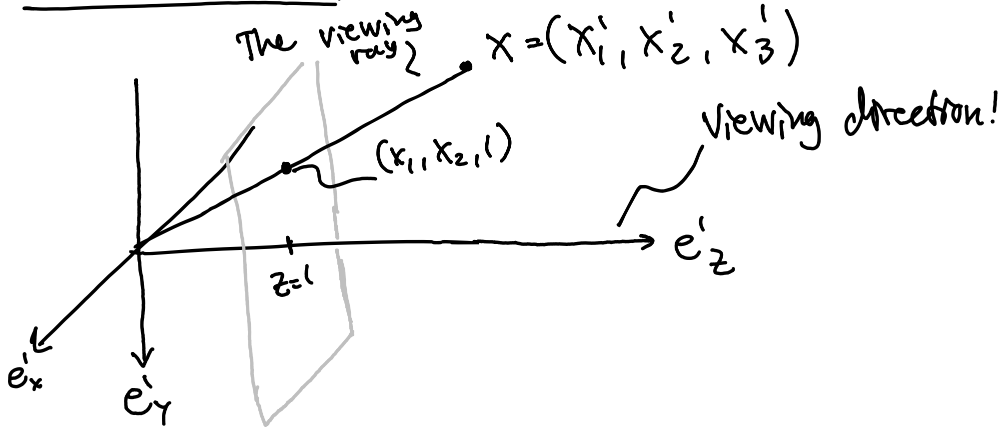
What is computer vision?

computer graphics, comp. vision

3D → 2D 2D → 3D.

Main goal: multiview reconstruction.

Pinhole (camera) model, mathematical model:



The viewing ray:

$$(0,0,0) + s((x_1', x_2', x_3') - (0,0,0))$$

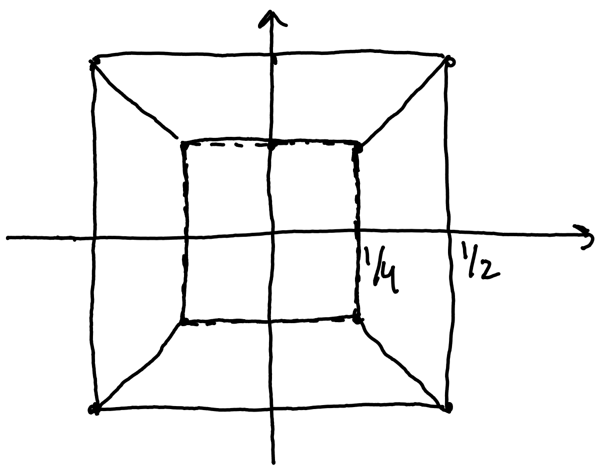
$$s x_3' = 1 \iff s = 1/x_3'$$

$$(x_1, x_2) = (x_1'/x_3', \; x_2'/x_3')$$

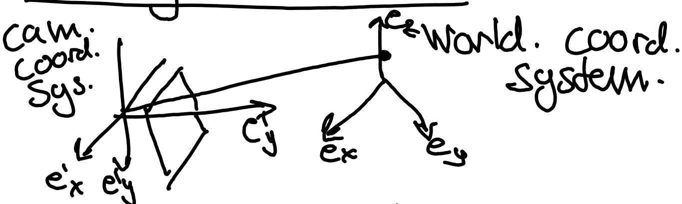
Ex 1:

projection of $(\pm 1, \pm 1, 2)$ is $\left(\frac{\pm 1}{2}, \frac{\pm 1}{2}\right)$

—— " —— $(\pm 1, \pm 1, 4)$ is $\left(\frac{\pm 1}{4}, \frac{\pm 1}{4}\right)$



Moving cameras:

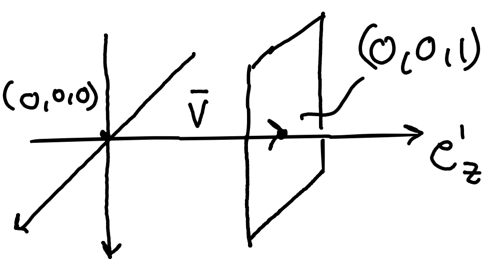


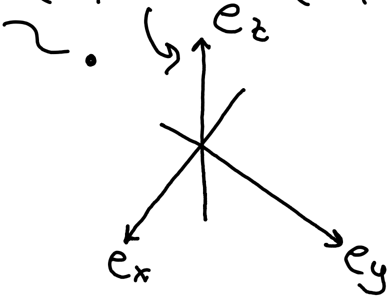
Relationship between coord. systems

$$\begin{pmatrix} x_1' \\ x_2' \\ x_3' \end{pmatrix} = \underset{\substack{\uparrow \\ \text{rotation} \\ \text{matrix} \\ 3\times 3}}{R} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \underset{\substack{\uparrow \\ \text{vector} \\ 3\times 1}}{t}$$

Ex 2:

$$X = (x_1, x_2, x_3) = (x_1', x_2', x_3')$$





$$\begin{pmatrix} x_1' \\ x_2' \\ x_3' \end{pmatrix} = R \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + t$$

Computer center

$$\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} = RC + t \iff 0 = RC + t \iff$$

$$RC = -t \iff C = -R^{-1} t = \underline{-R^T t}$$

(0,0,1):

$$\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} = RX + t \iff X = \underbrace{R^T \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}}_{\substack{\text{last row} \\ \text{of } R = R_3}} \underbrace{- R^T t}_{= C}$$

$$X = R_3 + C$$

Viewing direction: $X - C = R_3 + C - C = \underline{R_3}$

Camera matrice:

comp the proj. (from world coord to img. plane)

$$x_3' \begin{pmatrix} x_1'/x_3' \\ x_2'/x_3' \\ 1 \end{pmatrix} = \begin{pmatrix} x_1' \\ x_2' \\ x_3' \end{pmatrix} = \underset{3\times 4}{[R \quad t]} \underset{4\times 1}{\begin{pmatrix} X_1 \\ X_2 \\ X_3 \\ 1 \end{pmatrix}}$$

Algo:

1. comp. $v = [R \quad t]\begin{bmatrix} X \\ 1 \end{bmatrix}$
2. Divide v with its third coordinate

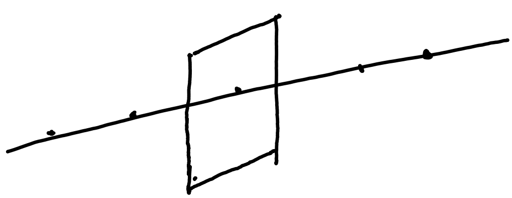
Ex 3: compute the projection of $X_1 = (0,0,-1)$ in the camera

$$P = \frac{1}{3}\begin{pmatrix} 1 & 2 & 2 & 0 \\ 2 & 1 & -2 & 0 \\ -2 & 2 & 1 & 1 \end{pmatrix}$$

What other points gives the same projection?

$$\frac{1}{3}\begin{pmatrix} 1 & 2 & 2 & 0 \\ 2 & 1 & -2 & 0 \\ -2 & 2 & 1 & 1 \end{pmatrix}\begin{pmatrix} 0 \\ 0 \\ -1 \\ 1 \end{pmatrix} = \frac{1}{3}\begin{pmatrix} -2 \\ 2 \\ 2 \end{pmatrix} = v$$

Projection is $(-1, 1)$



$$v = \lambda\begin{pmatrix} -1 \\ 1 \\ 1 \end{pmatrix} = RX_1 + t \iff RX = \lambda\begin{pmatrix} -1 \\ 1 \\ 1 \end{pmatrix} - t$$

$$X = R^T\left(\lambda\begin{pmatrix} -1 \\ 1 \\ 1 \end{pmatrix} - t\right)$$

$$X = \frac{1}{3}\begin{pmatrix} 1 & 2 & -2 \\ 2 & 1 & 2 \\ 2 & 2 & -1 \end{pmatrix}\left(\lambda\begin{pmatrix} -1 \\ 1 \\ 1 \end{pmatrix} - \frac{1}{3}\begin{pmatrix} 0 \\ 6 \\ 1 \end{pmatrix}\right) = \lambda \underbrace{\frac{1}{3}\begin{pmatrix} -1 \\ 1 \\ 5 \end{pmatrix}}_{\text{dir vector}} + \underbrace{\frac{1}{9}\begin{pmatrix} 2 \\ -2 \\ 1 \end{pmatrix}}_{\text{starting point}}$$

If $\lambda = 2/3$ we get $\begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix}$

Depth of a Point: = z-coord. in cam. coord. system.

A point is in front of the camera if Depth > 0

A point is behind of the camera if Depth < 0