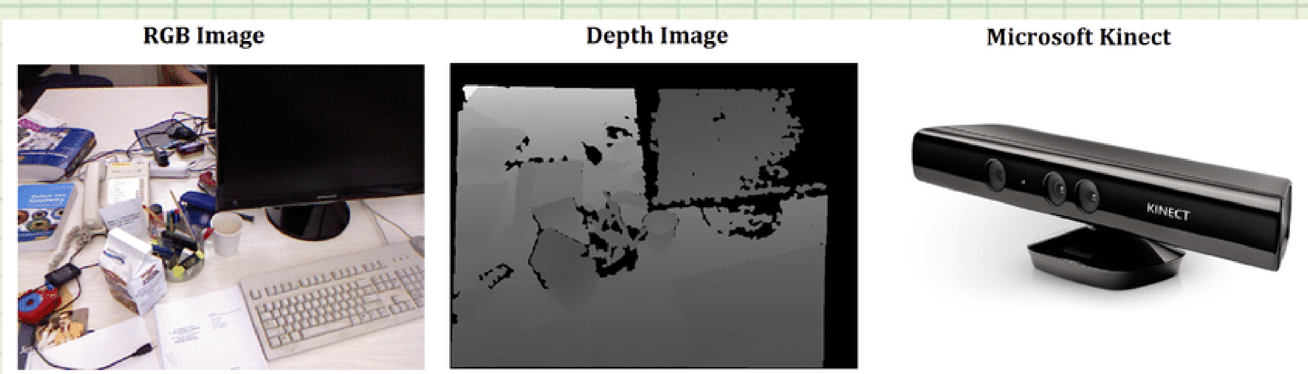
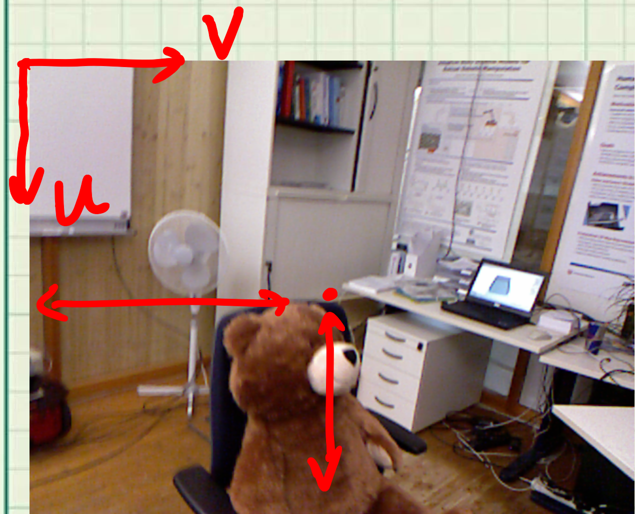
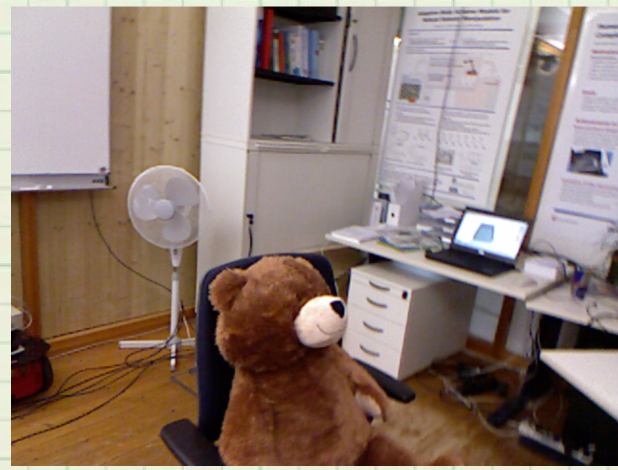
Lecture 18:

F2F RGB-D Registration (visual odometry)



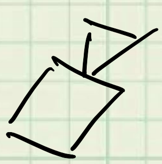
Goal: Track the camera pose temporally





t_1 $\quad\longrightarrow\quad$ t_2

I_1 $\quad T \in SE(3) \quad$ I_2



Camera projection model

$$P = \begin{bmatrix} x \\ y \\ z \end{bmatrix} \in \mathbb{R}^3$$ 3D point

$$\begin{bmatrix} u \\ v \end{bmatrix} = \pi(P) = \begin{bmatrix} \frac{f_x x}{z} + c_x \\ \frac{f_y y}{z} + c_y \end{bmatrix}_{2\times 1}$$

→ pixels on the image

I_1 (320x240) I_2

measurements

Assumption: Brightness constancy

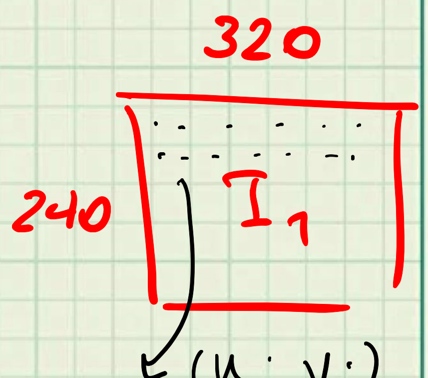
$$\begin{bmatrix} u_i \\ v_i \end{bmatrix} = \pi(P_i) \quad , \quad I_i(u_i, v_i) \in \mathbb{R}^+$$

$$r_i(T) = I_2(\pi(T \cdot P_i)) - I_1(\pi(P_i))$$

$$T \cdot P_i = R P_i + t$$

$$T = (R, t) \in SE(3)$$

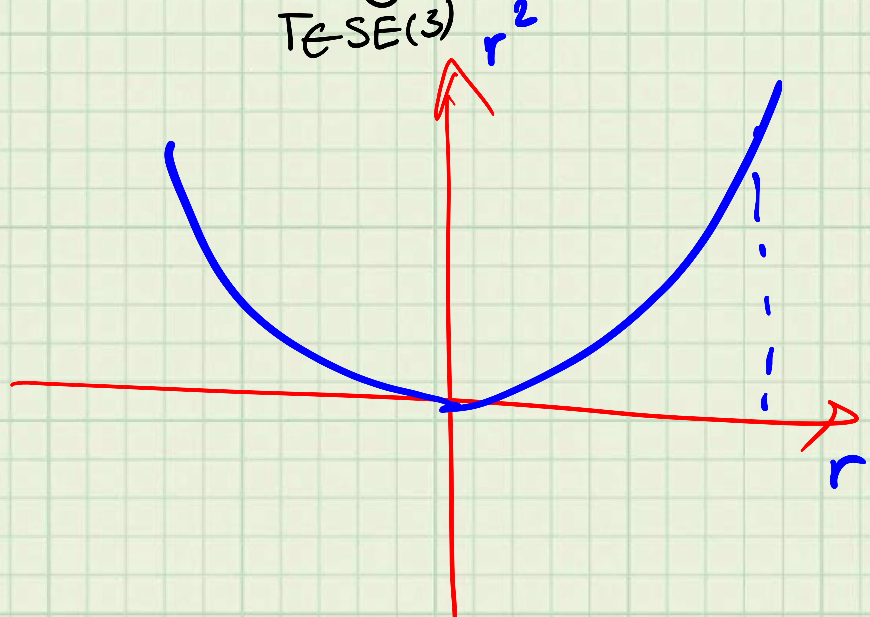
$$i = 1, 2, \dots, 240 \times 320$$



$$P_i = \begin{bmatrix} x_i \\ y_i \\ z_i \end{bmatrix}$$

Photometric Loss Function

$$T^* = \underset{T \in SE(3)}{\arg\min} \sum_i r_i^2(T)$$



M_estimator, a.k.a, Robust RGB-D VO

$$T^* = \underset{T \in SE(3)}{\arg\min} \sum \rho\left(r_i^2(T)\right)$$

$\rho(\cdot)$ is the robust kernel or norm,

e.g., Cauchy loss function.

We can solve this problem using IRLS.

Ceres solver

$$\min_{T} \; r^T W r$$

$$r(\xi) \approx A_{1\times 6}\, \xi_{6\times 1} + b_{1\times 1}$$

$$A_i = \sqrt{\omega_i}\, \frac{\partial r_i}{\partial \xi} \qquad (1\times 6)$$

$$A = \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_n \end{bmatrix}_{n\times 6}, \quad n = 240 \times 320$$

Normal Equation:

$$A^T A\, \xi = -\sqrt{W} A^T r$$

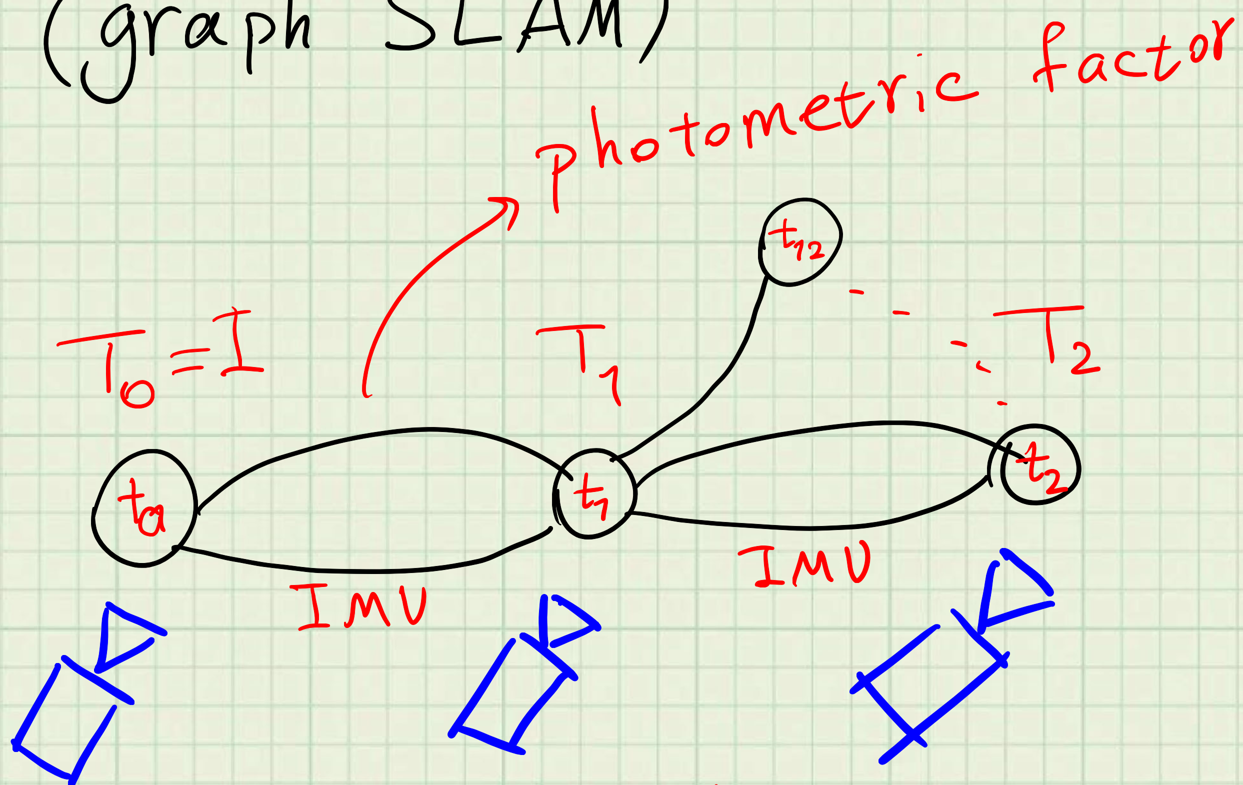
$$\left(\sum_i A_i^T A_i\right) \xi = -\sum_i \sqrt{\omega_i}\, A_i$$

$$H \xi = d \implies \xi = H \backslash d$$

Next Time:

Sensor fusion using factor graphs

(graph SLAM)



GTSAM (iSAM solver)