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REU
WEEK 3 PRESENTATION

The problem

- How do we accurately detect ego-motion using optical flow?
- What can we do now that we know how the camera has moved?
- Current Objectives
  - Accurately detect how much the system has moved
  - Accurately detect how much the system has rotated

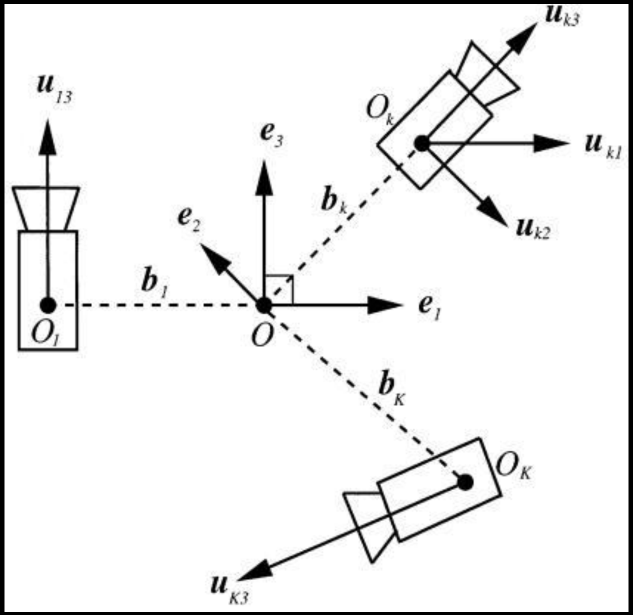
The experiment

- What's the optical flow in this sequence?

The literature

- Read and comprehended the following papers:
  - Pyramidal Implementation of the Lucas Kanade Feature Tracker Description of the algorithm – Bouguet
  - Passive Navigation – Bruss and Horn
  - Ego-motion Estimation Using Optical Flow Fields Observed from Multiple Cameras – Tsao et al

The setup



$$C_g = \{O, \mathbf{I} = [\mathbf{e}_1 | \mathbf{e}_2 | \mathbf{e}_3]\}$$

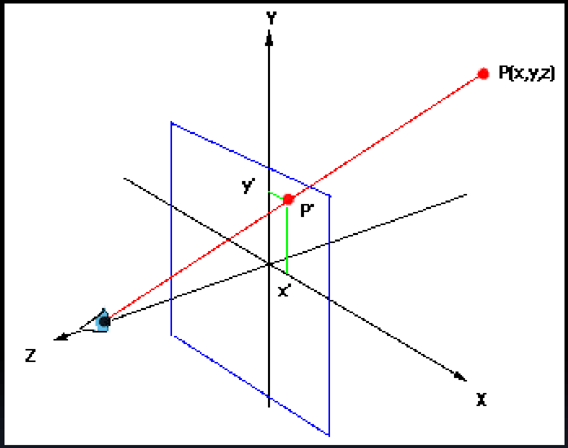
$$C_k = \{\mathbf{b}_k, \ \boldsymbol{R}_k = [\mathbf{u}_{k1} | \mathbf{u}_{k2} | \mathbf{u}_{k3}]\}$$

The problem

- Relative to Cg, the following is true from the perspective projection model:

$$\dot{\mathbf{P}}_k = -\boldsymbol{\omega}_k \times \mathbf{P}_k - \mathbf{t}_k$$

$$\mathbf{p}_k \equiv \begin{bmatrix} p_{xk} \\ p_{yk} \\ 1 \end{bmatrix} = \frac{1}{P_{zk}} \mathbf{P}_k$$



- Differentiate (2) and substitute (1):

$$\mathbf{v}_k \equiv \dot{\mathbf{p}}_k = -\left(\omega_k \times \mathbf{p}_k\right) - \frac{\dot{P}_{zk}}{P_{zk}} \mathbf{p}_k - \frac{1}{P_{zk}} \mathbf{t}_k$$

The problem

- Plug-in the following and simplify:

$$\boldsymbol{\omega}_k \equiv \boldsymbol{R}_k^T \boldsymbol{\omega} \text{ and } \mathbf{t}_k \equiv \boldsymbol{R}_k^T [(\boldsymbol{\omega} \times \mathbf{b}_k) + \mathbf{t}]$$

- To get:

$$\mathbf{m}_{ki}^T (\mathbf{h}_k + \mathbf{t}) = 0$$

$$\mathbf{h}_k \equiv \boldsymbol{\omega} \times \mathbf{b}_k$$

$$\mathbf{m}_{ki} \equiv \boldsymbol{R}_k \{\mathbf{p}_{ki} \times \left[\dot{\mathbf{p}}_{ki} + (\boldsymbol{R}_k^T \boldsymbol{\omega} \times \mathbf{p}_{ki})\right]\}$$

The problem

- Take this:

$$J_1'(\omega, \mathbf{t}) \equiv \sum_{k=1}^{K} \sum_{i=1}^{N_k} \|\mathbf{m}_{ki}^T(\mathbf{h}_k + \mathbf{t})\|^2$$

- And solve for t:

$$\mathbf{t} = M^{-1}\mathbf{c}$$

$$M \equiv \sum_{k=1}^{K} \sum_{i=1}^{N_k} \mathbf{m}_{ki}\mathbf{m}_{ki}^T \text{ and } \mathbf{c} \equiv -\sum_{k=1}^{K} \sum_{i=1}^{N_k} \mathbf{m}_{ki}\mathbf{m}_{ki}^T\mathbf{h}_k$$

- Plug t back in, now minimize the following:

$$J_1(\omega) \equiv -\mathbf{c}^T M^{-1} \mathbf{c} + \sum_{k=1}^{K} \sum_{i=1}^{N_k} (\mathbf{m}_{ki}^T \mathbf{h}_k)^2$$

The experiment

The problem

3D grid approach