Optical Flow: Week 3

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Project Outline

- **Goal** - Design a general purpose peripheral that uses optical flow to detect the user’s motion.
- **Restrictions** - Device must work in realtime and require no external sensors or markups.

- **Advisor** - Dr. Lobo
- **Associates** - Prince Gupta, Phillip Napieralski
Prototype

Figure: Top down

Figure: Side view

- **TARGET DESIGN** - Hand-held or wrist-fascened device
Related Works

Optical Flow Algorithm

- *Pyramidal Implementation of the Lucas Kanade Feature Tracker*
- Jean-Yves Bouguet
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Rotation and Translation detection

- Three-dimensional ego-motion estimation from motion fields observed with multiple cameras
- Yong-Sheng Chen, Lin-Gwo Liou, Yi-Ping Hung, Chiou-Shann Fuh
Ego-motion Summary

Given

- Multiple Cameras
- Origin/orientation of each camera
- Optical flow values for each camera

Minimize Equation to Determine \( \hat{\omega} \) and solve for \( \hat{t} \)

\[ J_1(\hat{\omega}) = -c^T M^{-1} c + \sum_{k=1}^{K} \sum_{i=1}^{N_k} (m_T k_i h_k)^2 \]

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Ego-motion Summary

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Minimize Equation to Determine $\hat{\omega}$ and solve for $\hat{t}$

$J_1$: error function

$M, c, h$: functions of $\omega_g$

$\hat{\omega}$: optimal estimate of $\omega_g$ (rotation)

$\hat{t}$: optimal estimate of $t_g$ (translation)

$$J_1(\omega_g) = -c^T M^{-1} c + \sum_{k=1}^{K} \sum_{i=1}^{N_k} (m_{ki}^T h_k)^2$$
Challenges

Optical Flow Problems

- Featureless environments
- Incompatible objects (large, uniform dark surfaces; redundant patterns)
- Distinguishing between translation and rotation
- Ego-motion works in theory, but must correctly minimize
Current Progress

Implementations

- System to determine optical flow from cameras (Prince Gupta)
- Implemented ego-motion algorithm (Phillip Napieralski)
- Optical flow generator to construct test data from ego-motion equations

Tasks completed by other members noted in parenthesis
Current Progress

Implementations\(^1\)

- System to determine optical flow from cameras (Prince Gupta)
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Recent Contributions

- Verified mathematics behind Ego-motion estimation
- Created single case test data sets for pure translation, pure rotation, and translation plus rotation
- Tested ego-motion algorithm with aforementioned data (Test failed)

\(^1\)Tasks completed by other members noted in parenthesis