TÉCNICO LISBOA

Institute for Systems and Robotics | LISBOA

Computer Vision – Visual-Inertial Odometry

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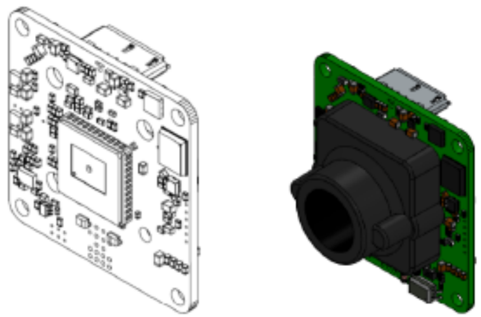
VIS LAB

Objectives

- Determine orientation during a saccade: 2 approaches
  - Standard camera and IMU
  - Event camera (José)
- Dataset recording
  - Kinova Gen3
  - Gimbal
- Experiments
- Future work

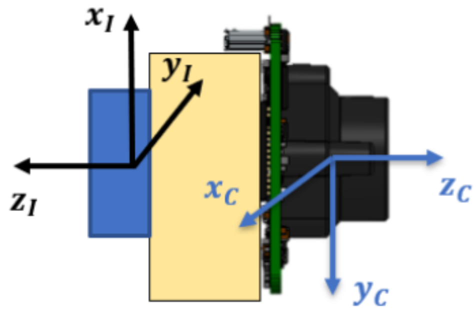
Approach 1: Standard camera and IMU (1)

1. Determine orientation of a camera embedded in a robotic eye.
2. Measure angular velocity and acceleration.
3. Minimize estimation error in the orientation (< 3 deg).



Approach 1: Standard camera and IMU (2)

- Camera rigidly attached to the IMU.
- Camera is good for low frequency orientation estimation but with motion blur problems.
- IMU for high frequency estimation but it has drift over time (error accumulation).



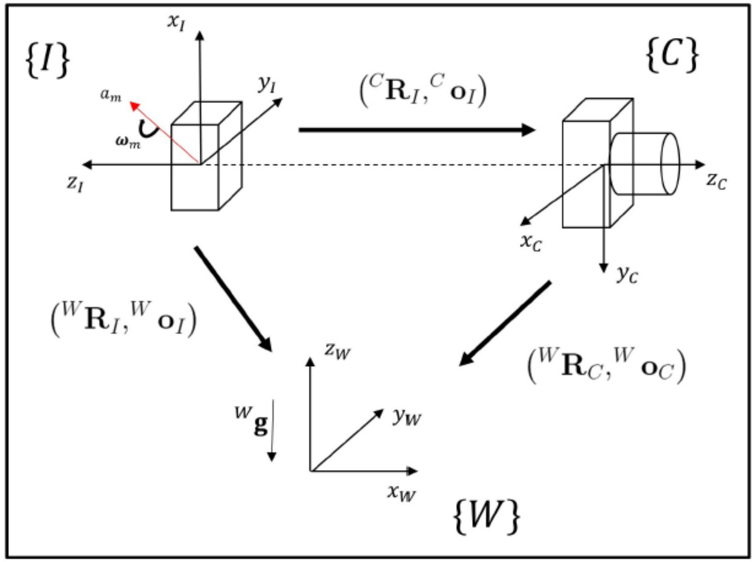
The sensors complement each other:

- The camera will take pictures at the beginning and end of saccades
- The IMU will be used to track the trajectory (through the gyroscope and accelerometer)

Sensor fusion

Solution: Unscented Kalman Filter (UKF) on Lie groups

- Relatively recent approach to solve this problem.
- Avoid computing derivatives of the EKF.
- UKF gives better performance.
- Assess the accuracy of the estimation using this method.



$$\mathbf{x}_k = (\chi_k, \mathbf{b}_k) \in SE(3)_{2+p} \times \mathbb{R}^6$$

$$\chi_k = \begin{bmatrix} \mathbf{R}_k & \mathbf{v}_k & \mathbf{o}_k & \mathbf{p}_1 \dots \mathbf{p}_p \\ \multicolumn{3}{c}{\mathbf{0}_{(2+p)\times 3}} & \mathbf{I}_{(2+p)} \end{bmatrix} \in SE(3)_{2+p}$$

$$\mathbf{b}_k = \begin{bmatrix} \mathbf{b}_k^{\mathbf{g}} \\ \mathbf{b}_k^{\mathbf{a}} \end{bmatrix} \in \mathbb{R}^6$$

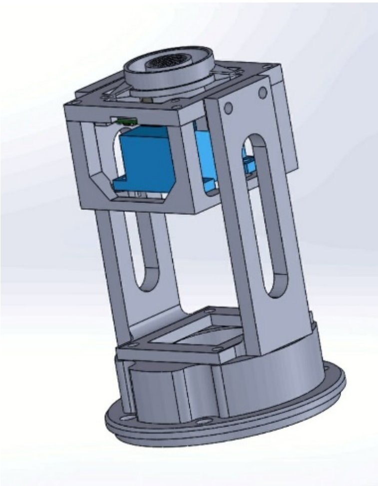
R_k – Orientation
v_k – Linear velocity
o_k – Position
$b_k^{g,a}$ – Biases (gyroscope and accelerometer)
$p_1 \dots p_p$ - Landmark positions

M. Brossard, S. Bonnabel, and A. Barrau. Invariant Kalman Filtering for Visual Inertial SLAM. In *21st International Conference on Information Fusion*, 21st International Conference on Information Fusion, Cambrige, United Kingdom, July 2018. University of Cambridge.

Dataset recording – Kinova Gen3

•Perform various saccade-like movements and record the trajectory.

•The Kinova is able to perform accurate movements but has speed limitations (the maximum speed is 50 deg/s).



Specifications

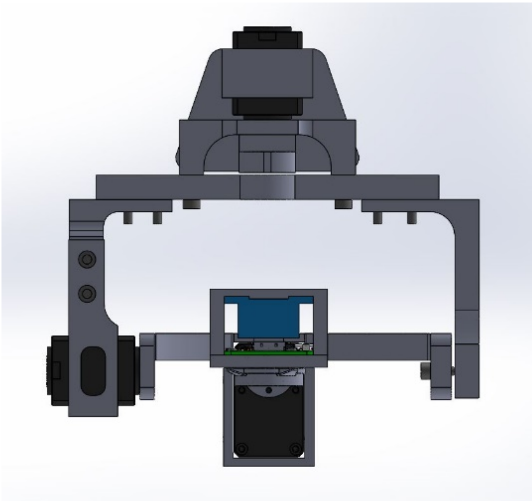
- 7 Degrees of freedom
- Easy to use
- Robust

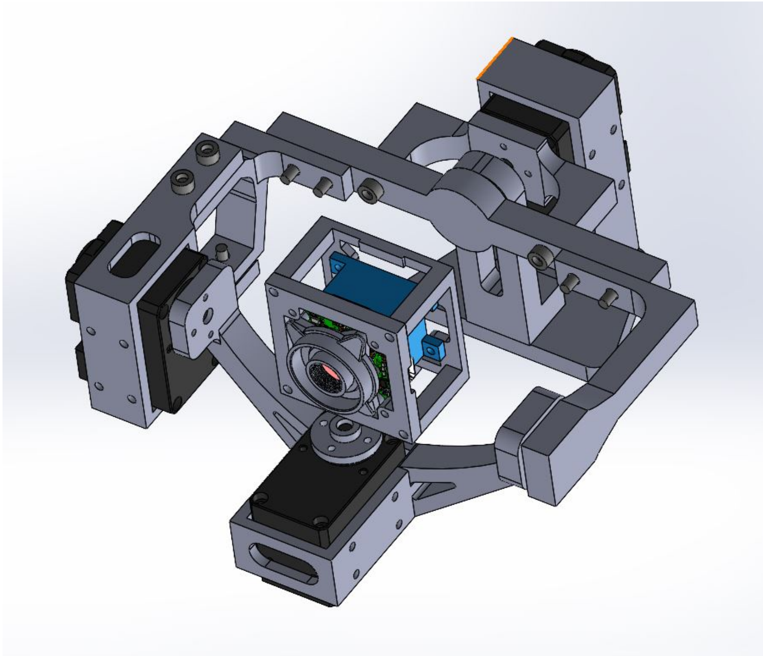
https://www.kinovarobotics.com/en/products/gen3-robot

Dataset recording - Gimbal

•Test faster saccade profiles to assess the filter's performance.

•Less precise than the Kinova.





Next steps

- Perform experiments.
- See the limitations and future work/upgrades.

Obrigado

Questions?