UNIVERSITY OF DELAWARE

RPNG

Award ID#: 1924897

NRI: FND: Consistent Distributed Visual-Inertial Estimation and Perception for Cooperative Unmanned Aerial Vehicles

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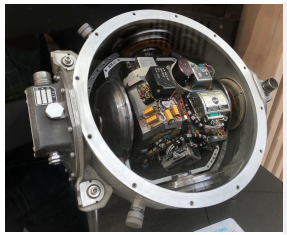
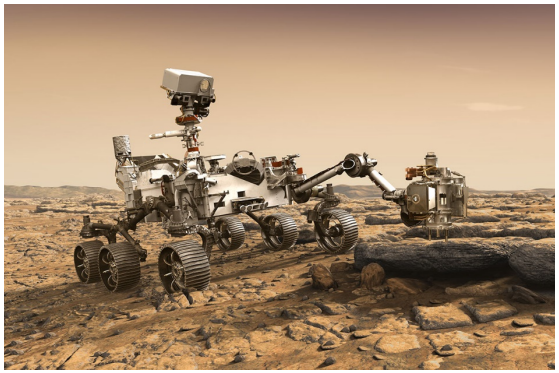
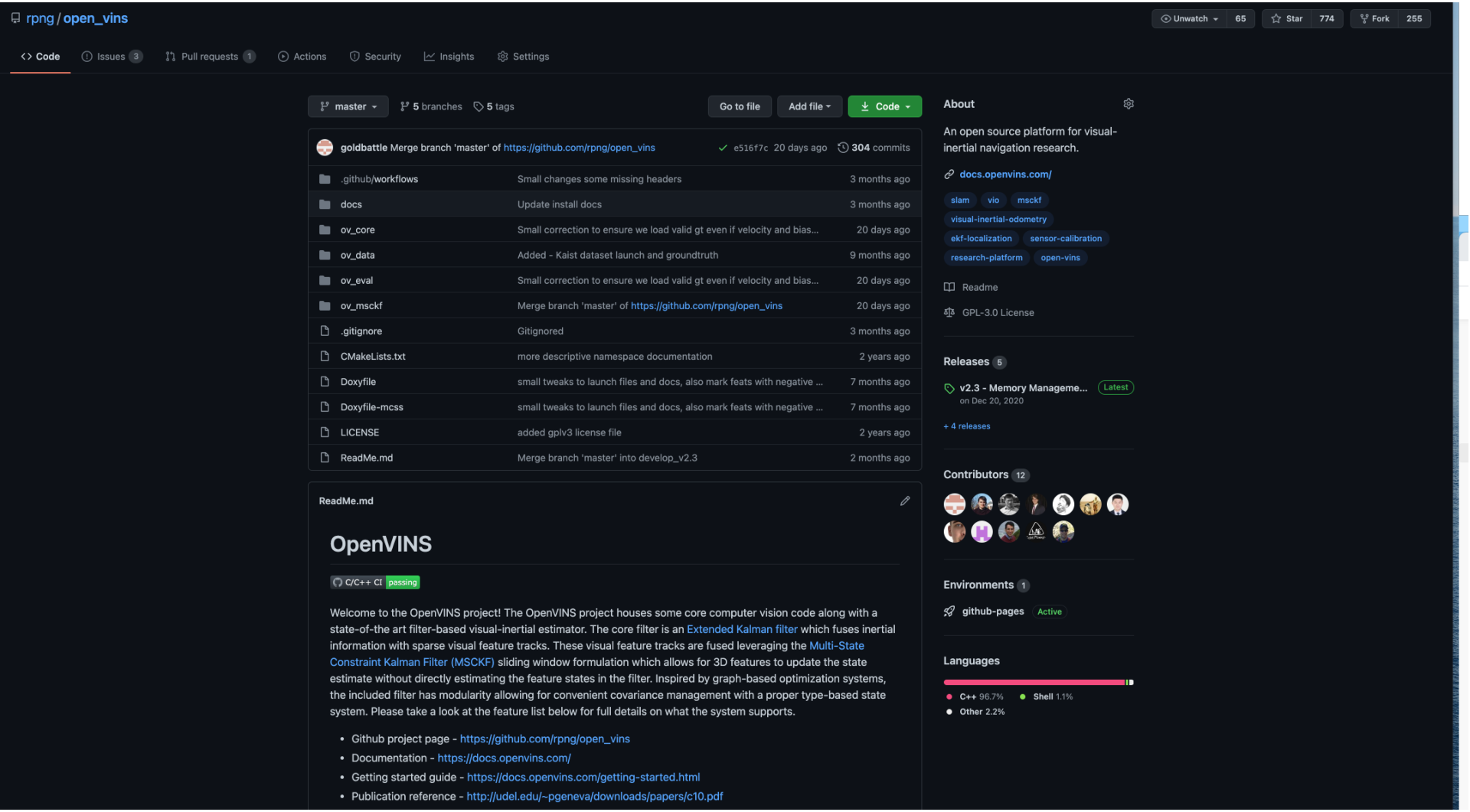
Visual-Inertial System

- Inertial measurement unit (IMU):
  - Pros: Providing high-rate 6DOF motion info. w/ scale
  - Cons: Biased, gravity-mixed, high-drift
- Camera:
  - Pros: Providing rich info., w/ low-drift motion
  - Cons: Scaleless, low-rate, lighting-dependent
- Visual-inertial sensor is appealing for 3D perception and navigation due to being lightweight and low cost, holding great potential in many applications:





OpenVINS: Open Platform for Visual-Inertial Estimation [ICRA 20a]



Open source: https://github.com/rpng/open_vins

Multi-IMU Multi-Camera (MIMC)-VINS [ICRA 19a, 19b; TRO 21]

- Goal: To design versatile and resilient MIMC-VINS that seamlessly fuses multi-modal information from an *arbitrary* number of uncalibrated cameras and IMUs, while providing smooth, uninterrupted, and accurate 3D motion tracking even if sensors fail
- Key ideas:
  - To perform high-order on-manifold state interpolation to efficiently process all available visual measurements without increasing the computational burden due to estimating additional sensors' poses at asynchronous imaging times.

$$
\begin{aligned}
{}^{G}\mathbf{p}_{I(t)} &\approx (1-\lambda)\,{}^{G}\mathbf{p}_{I(t_a)} + \lambda\,{}^{G}\mathbf{p}_{I(t_b)} \\
{}^{I(t)}_{G}\mathbf{R} &\approx \mathrm{Exp}\left(\lambda \mathrm{Log}\left({}^{I(t_b)}_{G}\mathbf{R}\,{}^{G}_{I(t_a)}\mathbf{R}\right)\right){}^{I(t_a)}_{G}\mathbf{R} \\
\lambda &= \frac{t-t_a}{t_b-t_a}
\end{aligned}
$$

  - To propagate a joint system consisting of all IMU states while enforcing rigid-body constraints between the IMUs during the filter update stage
  - To estimate online both spatiotemporal extrinsic and visual intrinsic parameters to be robust to errors in prior sensor calibration

Results

MIMC-VINS: A Versatile and Resilient Multi-IMU Multi-Camera Visual-Inertial Navigation System

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Cooperative VIO [ICRA 21d]

Cooperative Visual-Inertial Odometry

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Summary

- Some of key results that we have achieved in 2020:
  - OpenVINS [ICRA 20a]
  - MIMC-VINS [ICRA 19a, 19b; TRO 21]
  - Online IMU intrinsic calibration [RSS 20]
  - Visual-inertial-wheel odometry with online calibration [ICRA 20b]
  - Schmidt-EKF-based visual-inertial moving object tracking [ICRA 20c]
  - Cooperative visual-inertial odometry [ICRA 21a]

- My Lab: Robot Perception and Navigation Group (RPNG)

YouTube

GitHub

Thank you!