

Award ID#: 1924897

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

Guoquan (Paul) Huang

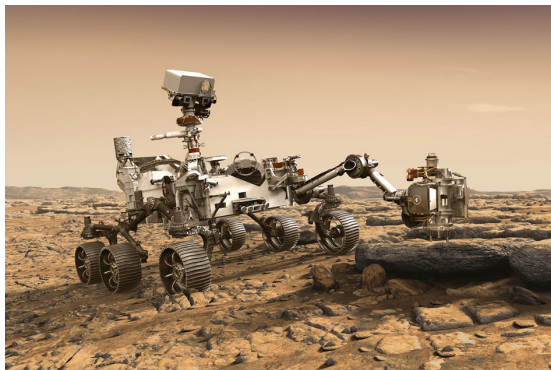
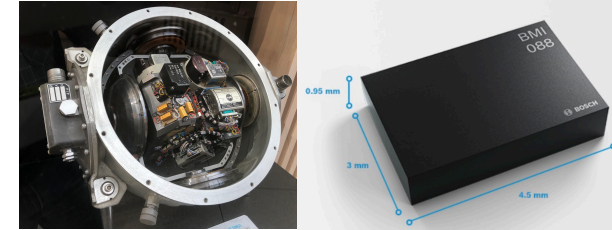
University of Delaware (UD)

Poster #: 53

NSF NRI Virtual PI Meeting, March 10-11, 2021

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]

The screenshot displays the GitHub repository interface for `rpng/open_vins`. At the top, navigation links include Code, Issues (3), Pull requests (1), Actions, Security, Insights, and Settings. The repository is currently on the `master` branch, with 5 branches and 5 tags. A commit by `goldbattle` is highlighted, showing a merge of the `master` branch. The file list includes `.github/workflows`, `docs`, `ov_core`, `ov_data`, `ov_eval`, `ov_msckf`, `.gitignore`, `CMakeLists.txt`, `Doxyfile`, `Doxyfile-mcss`, `LICENSE`, and `ReadMe.md`. The `ReadMe.md` content is visible, featuring the OpenVINS logo and a CI status of 'passing'. The README text reads: 'Welcome to the OpenVINS project! The OpenVINS project houses some core computer vision code along with a state-of-the-art filter-based visual-inertial estimator. The core filter is an Extended Kalman filter which fuses inertial information with sparse visual feature tracks. These visual feature tracks are fused leveraging the Multi-State Constraint Kalman Filter (MSCKF) sliding window formulation which allows for 3D features to update the state estimate without directly estimating the feature states in the filter. Inspired by graph-based optimization systems, the included filter has modularity allowing for convenient covariance management with a proper type-based state system. Please take a look at the feature list below for full details on what the system supports.' The right sidebar shows repository statistics: 65 Unwatch, 774 Star, and 256 Fork. It also includes sections for About (describing the platform), docs (`docs.openvins.com`), Releases (v2.3 - Memory Manageme... on Dec 20, 2020), Contributors (12), Environments (1), and Languages (C++ 96.7%, Shell 1.1%, Other 2.2%).

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.

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

- 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

Kevin Eickenhoff, Patrick Geneva, and Guoquan Huang

RPNG, University of Delaware, USA

Cooperative Visual-Inertial Odometry

Pengxiang Zhu¹, Yulin Yang², Wei Ren¹ and Guoquan Huang²

¹ Cooperative Vehicle Networks (COVEN) Lab, University of California, Riverside, USA

² Robot Perception and Navigation Group (RPNG), University of Delaware, USA

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!