
Amr Suleiman, Zhengdong Zhang, Luca Carlone, Sertac Karaman, and Vivienne Sze

Demo: Trevor Henderson and Diana Wofk

Motivation

Autonomous navigation of nano drones

No GPS

Use images and inertial data for state estimation

Location (Trajectory)

3D Map

Virtual and augmented reality on energy-constrained devices

Vision Frontend (VFE)

Feature Detection (Identify features)

• Extract Harris corners (up to 200 per frame)
• Search and distribute across the whole frame
• Compute for every keyframe

3D Stereo (Estimate depth of features – a.k.a. landmarks)

• Sparse block matching
• Compute for every keyframe

Feature Tracking (Estimate movement of features)

• Lucas-Kanade pyramidal optical flow
• Supports up to 3 pyramid levels
• Compute for all frames (measure movement between keyframes)

Back end (BE)

Minimize inconsistencies between measurements across time

Fuses vision and IMU estimates to refine the final state estimates ($x'$)

Over 4000+ factors in optimization

Navion Chip Architecture

VIO: Visual-Inertial Odometry

VIO is a special instance of Simultaneous Localization and Mapping (SLAM)

Input to Vision Front-end (VFE)

Graph optimization

3D feature tracks

Drone’s states in horizon: $x(1), x(2), \ldots, x(t)$

Update state estimates ($x'$)

Solve with state-of-the-art factor graph algorithm

Navion Results

Key Challenges

• Large frame memories for feature tracking and stereo computation
• Large graph memory with irregular memory access
• Slow linear solver

Our Approach

• Image compression
  • 4.4x smaller frame memory
  • 4.9x less power
• Sparse feature tracks data structure
  • 5.4x smaller graph memory
• Sparse linear solver
  • 5.2x smaller linear solver memory
  • 7.2x speed up

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Gyroscope: Estimate Rotation

Accelerometer: Estimate Translation

Pre-integration: Integrate IMU measurements into one per keyframe [1]

Navion Chip Architecture

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