LIPS: LiDAR-Inertial 3D Plane SLAM

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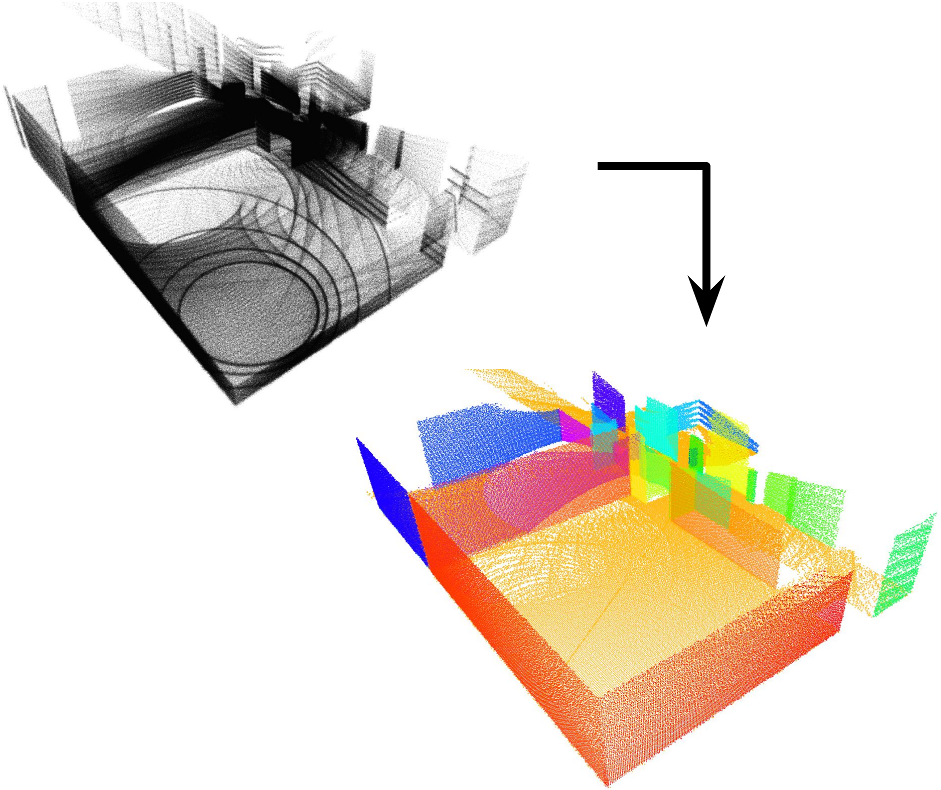
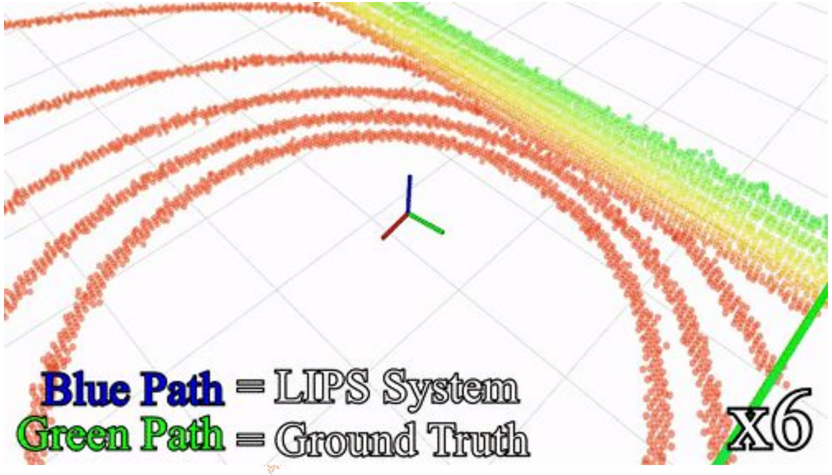
Motivation

- Want to combine higher level primitives (e.g., planes) in structured environments
- Take advantage of properties of LiDAR and IMU sensors
- Address representation for plane primitives



LIPS System Overview

1. Extract planes from LiDAR pointclouds
2. Compress each into *Closest Point* plane representation with covariance
3. Formulate as LiDAR-aided *inertial* graph SLAM with continuous IMU preintegration

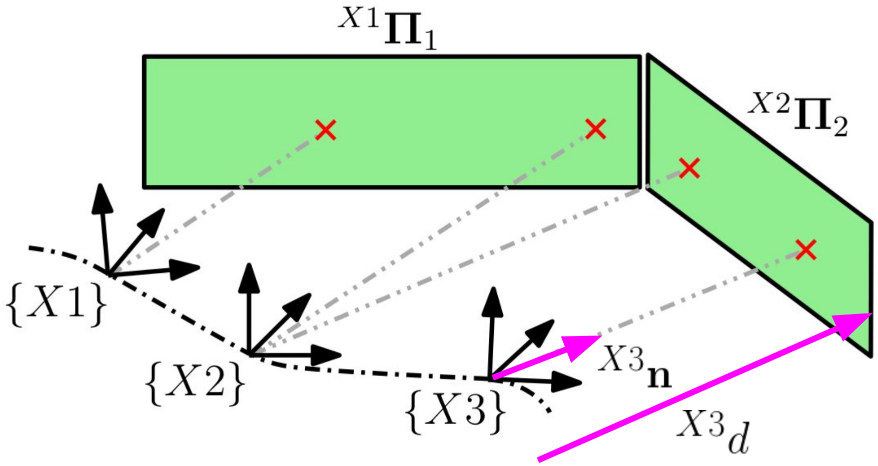


Closest Point Plane Representation

- The plane is represented as:

*The 3D point that resides on the plane and is the **closest** to the current frame's origin.*

- Minimal error state (3D point) is in Euclidean space
- Plane is represented in "anchoring" frame to avoid singularity when d->0

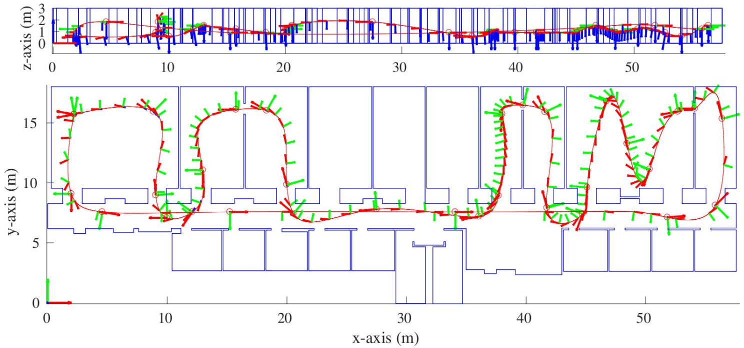


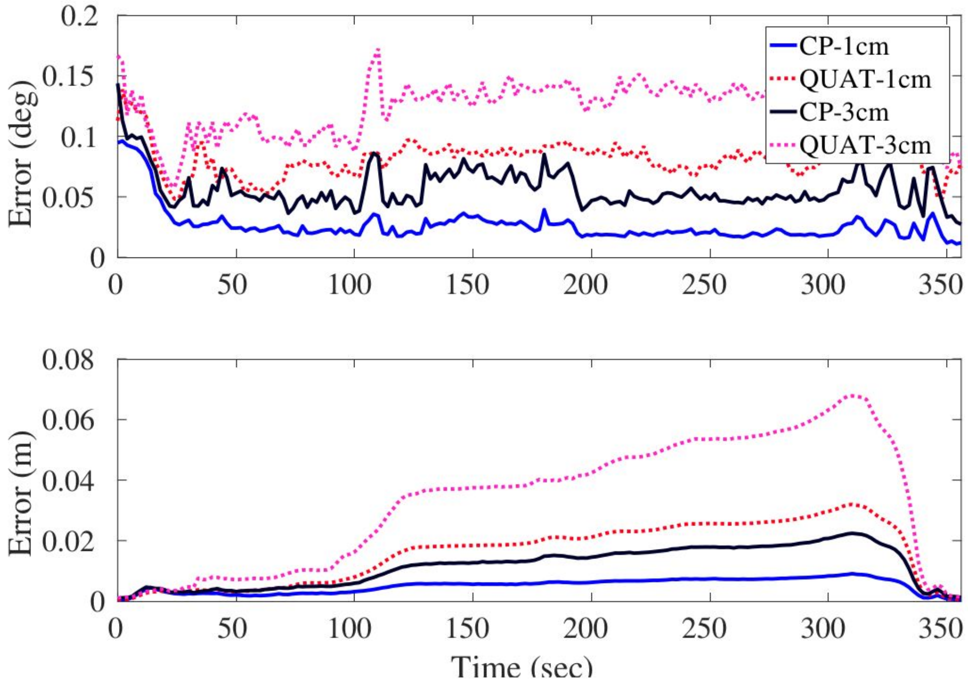
$$^{G}\mathbf{\Pi} = {}^{G}\mathbf{n}\ {}^{G}d$$

$$\begin{bmatrix} ^{G}\mathbf{n} \\ ^{G}d \end{bmatrix} = \begin{bmatrix} ^{G}\mathbf{\Pi}/\|^{G}\mathbf{\Pi}\| \\ \|^{G}\mathbf{\Pi}\| \end{bmatrix}$$

Results - Simulation

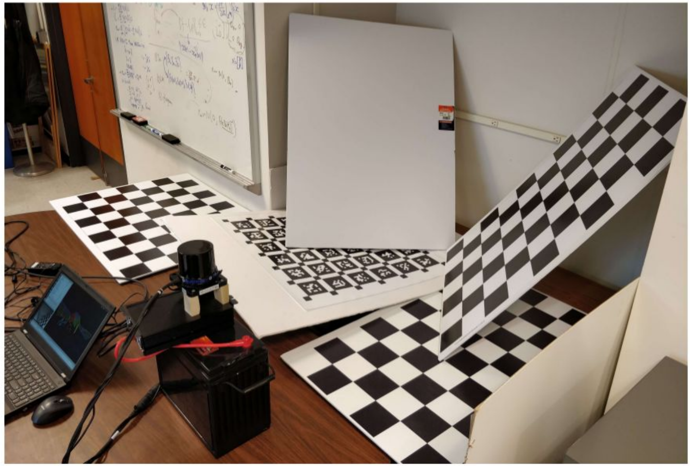
- Compared against Quaternion representation [Kaess 2015]
- Simulated 180m long trajectory

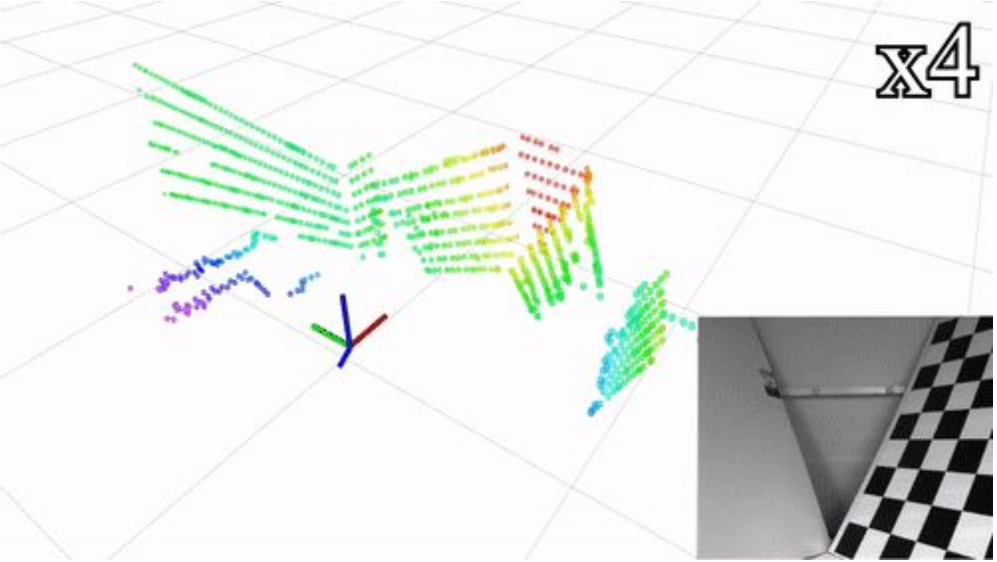




Results - Realworld

- Small scale realworld experiment
- Plane extraction speed limiting factor
- Good scene reconstruction





Conclusion - LiDAR-aided Inertial Plane SLAM

- Introduced *Closest Point (CP)* plane representation
- Fused *Closest Point (CP)* planes with IMU continuous preintegration
- Verified ***LIPS*** with simulation and realworld experiments

Simulator: *https://github.com/rpng/lips*

Continuous Preintegration: *https://github.com/rpng/cpi*

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