Multi-Agent Mapping in GPS-Denied Environment

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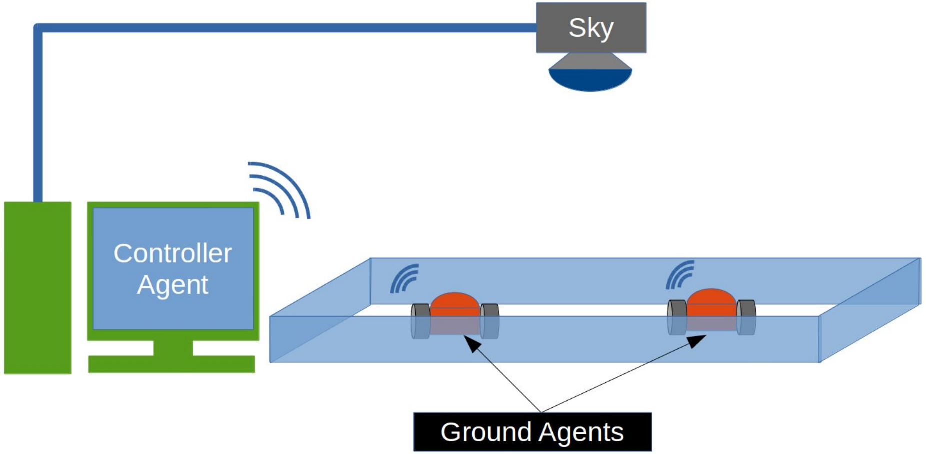
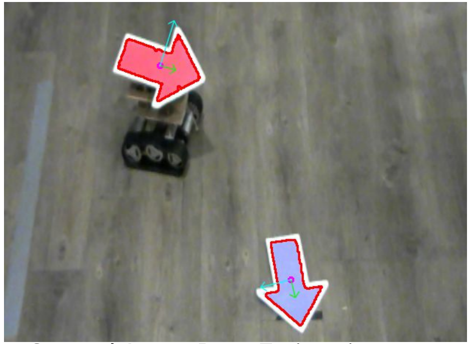
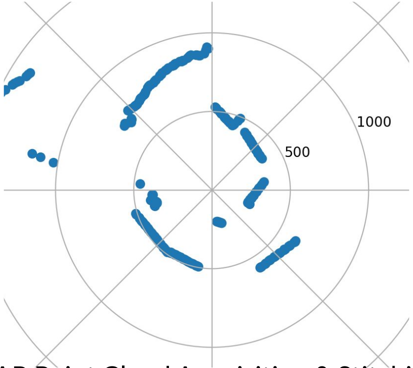
Motivation



- Construct a low-cost, low-resource solution to Simultaneous Localization and Mapping (SLAM) without GPS
- Develop a software framework and physical prototype to test and improve different Multi-Agent Mapping Algorithms

Objectives

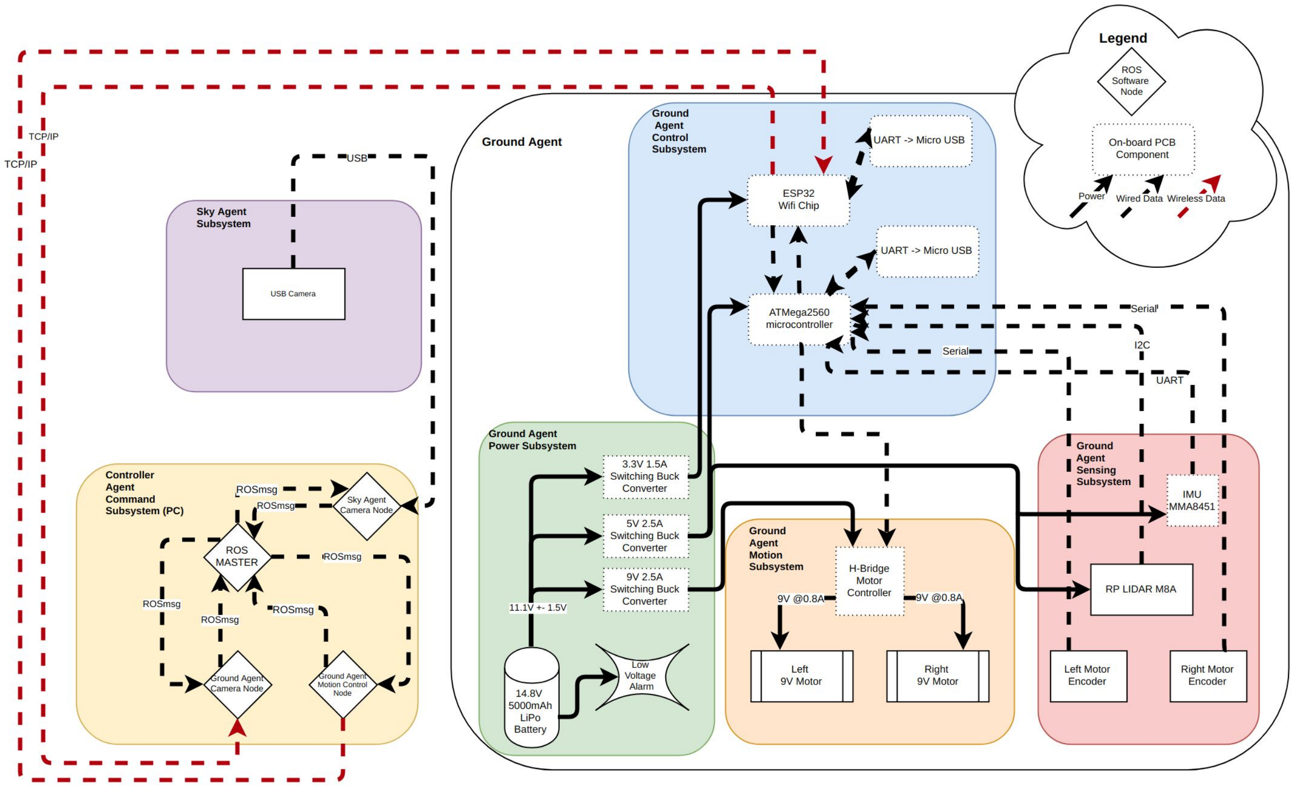

Ground Agent Pose Estimation



LIDAR Point Cloud Acquisition & Stitching

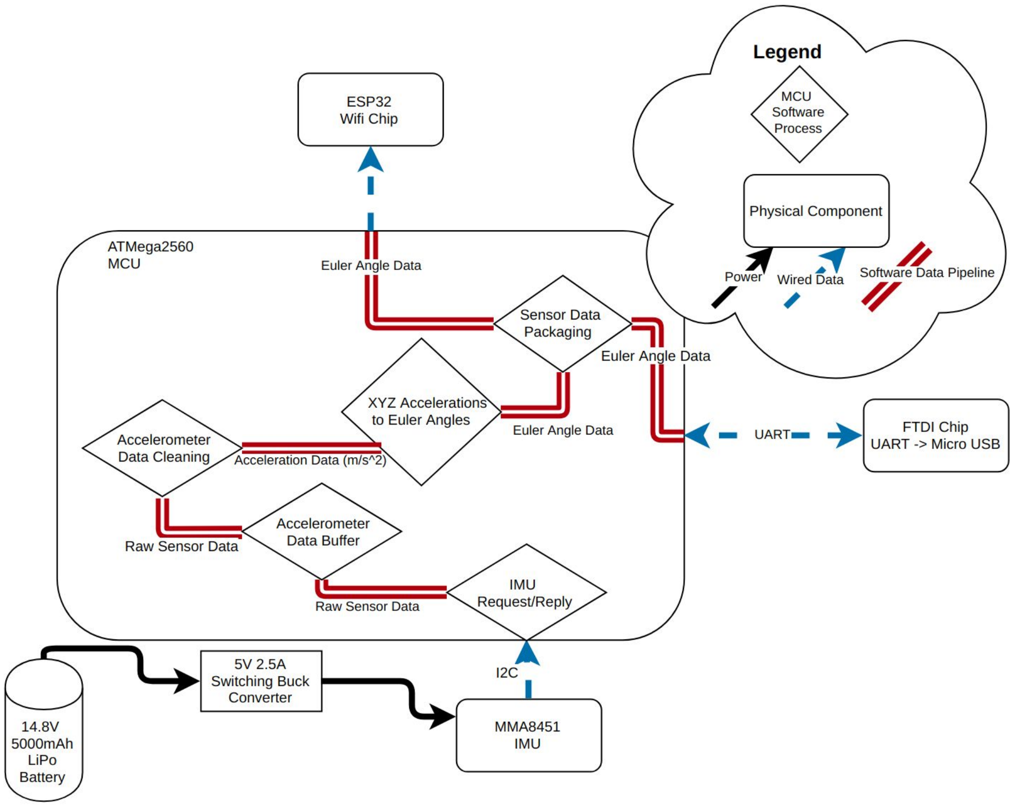
- Localize Ground Agent position and orientation with Sky Agent
- Map obstacles around each Ground Agent with low-cost LIDAR
- Stitch LIDAR data to create global map of environment

High-Level Block Diagram



IMU

Inertial Measurement Unit



IMU Data Mapping

1. Anticipating no more than 19.6 m/s^2 acceleration, we set the IMU to a resolution of 2G.
2. The IMU outputs a 14-bit reading for each coordinate axis (from-8192 to 8191).
3. We map this data onto the range {-19.6,19.6} m/s^2 to get our inertial reading.

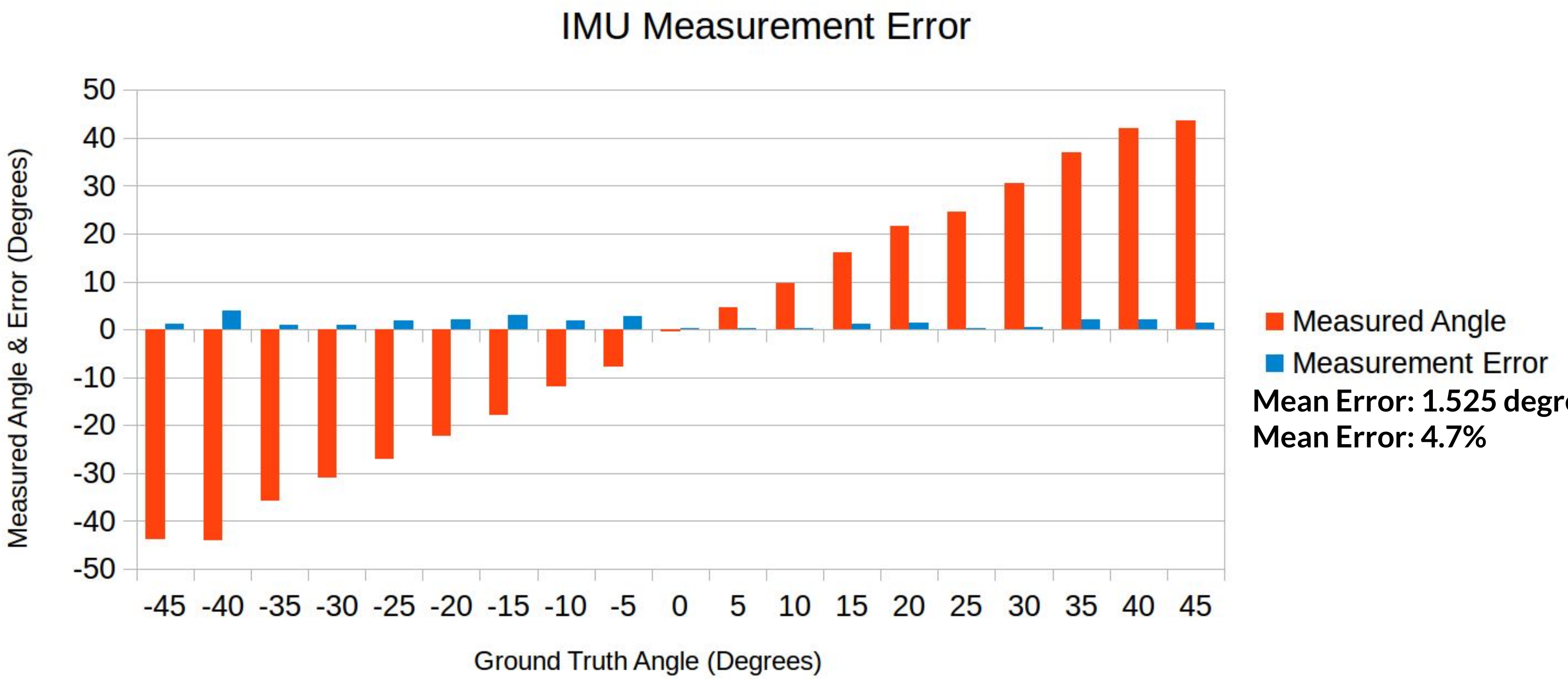
IMU Data Conversion

In order to calculate Pitch angle, we utilize all three accelerations in the following formula:

$$Pitch = \frac{180}{\pi} * tan^{-1} \frac{accelX}{\sqrt{accelY^2 + accelZ^2}}$$

This formula is implemented on the microcontroller for each IMU data sample, and passed out to the peripherals for logging and stitching purposes.

IMU Measurement Error Validation



Mean Error: 1.525 degrees
Mean Error: 4.7%

Lessons Learned (Software)

- SIFT performed poorly with extremely low-resolution video stream and inconsistent lighting
- Sensor data coming from our LIDAR was formatted as floating point numbers in a .txt file, but our LIDAR stitching algorithm required either .pcd or .pcl Point Cloud file format
- Granting superuser privilege caused multiple programs to crash mid-runtime, but had no problems in a new terminal with superuser privilege revoked
- Transforming the Sky Agent video stream into a birds-eye view after feature detection caused Ground Agent location and orientation data to be completely lost or corrupted

Lessons Learned (Hardware)

- For applications with sensitive instrumentation, Linear Power Regulators are a better solution, and cascading them will improve on any efficiency shortcomings
- Logic-level converters are necessary between 5v and 3v3 components to get usable data out of either component
- Investing in a higher quality chassis would dramatically improve motion performance
- Power supplies of each range were redundant, as many of the sensor component boards included 5v or 3v3 output at acceptable current ratings

Future Work

- Upgrade to a 4k webcam for improved Sky Agent feature detection performance
- Scale the number of agents and develop predictive models for occlusions/data dropping
- Integrate visualization of real-time map updates/creation via ROS in RViz