Robotics Hardware System Enabling Sensing and Autonomy Capabilities

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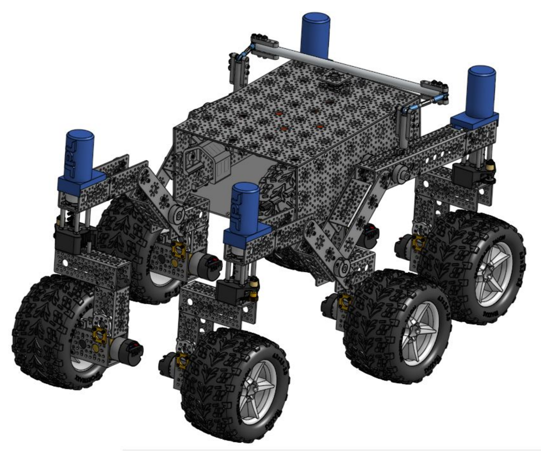
Open Source Rover - CADRE Program

- NASA's Cooperative Autonomous Distributed Robotic Explorers (CADRE) project is developing a network of robots that enables autonomous robotic exploration of the moon, mars, and beyond.
- The Open Source Rover (OSR) is the base platform that we use to extend the design, implementation, and integration.

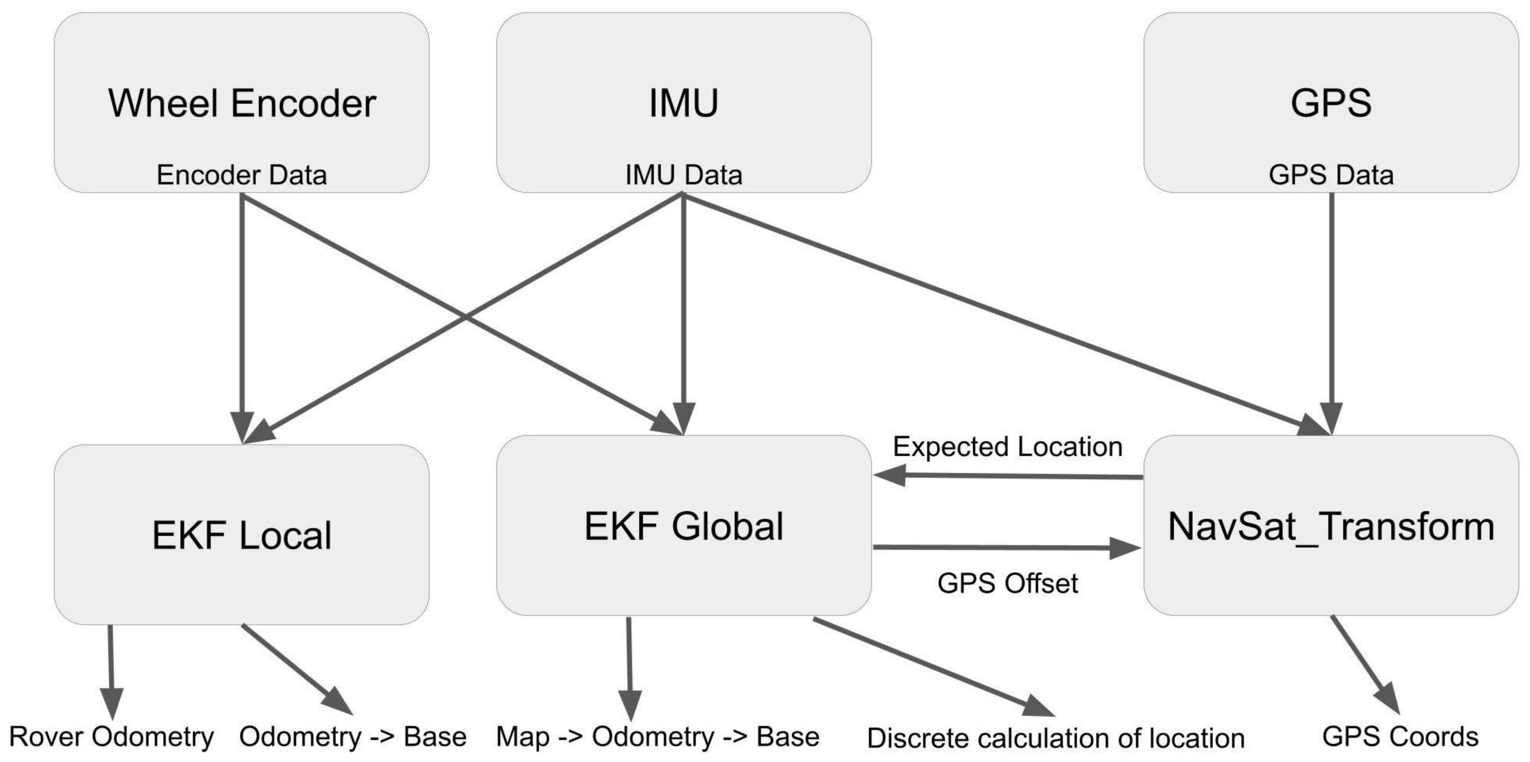


Problem Statement

By boosting the OSR base platform with sensing and computing capabilities, it shall fuses information about robot behavior and dynamics to demonstrate localization capabilities. As a stretch goal, the OSR enables intercommunication to allow the cooperative autonomous movement required by the CADRE program

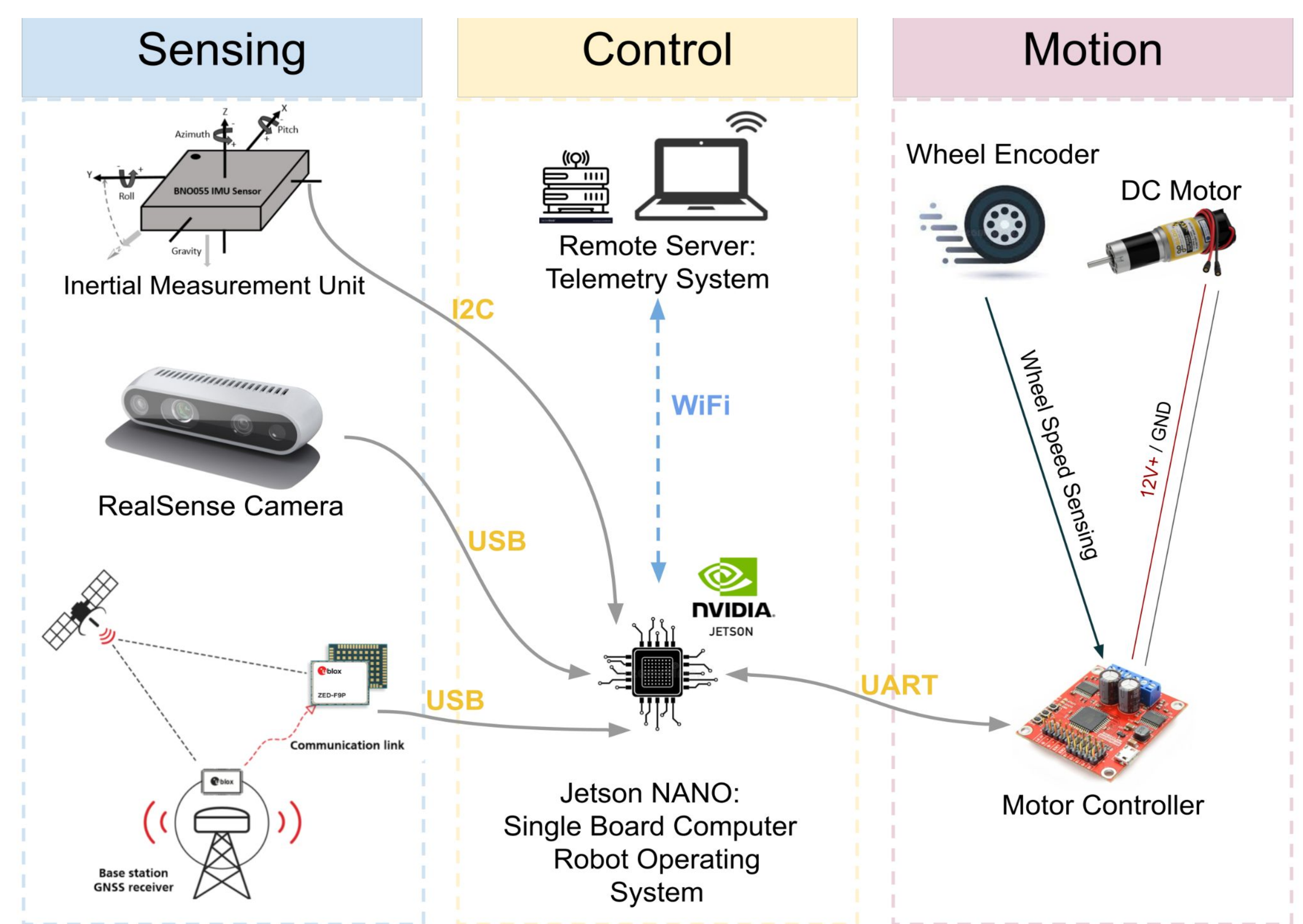
Robot Localization Concepts

- Extended Kalman Filter (EKF) fuses sensor data to determine robot pose.
- Our implementation utilizes local and global coordinate frames depending on the usage:
  - Local Coordinate Frame
    - Continuous fused sensor data
  - Global Coordinate Frame
    - Discrete Pose Estimation



Electrical System Design & Sensor Fusion

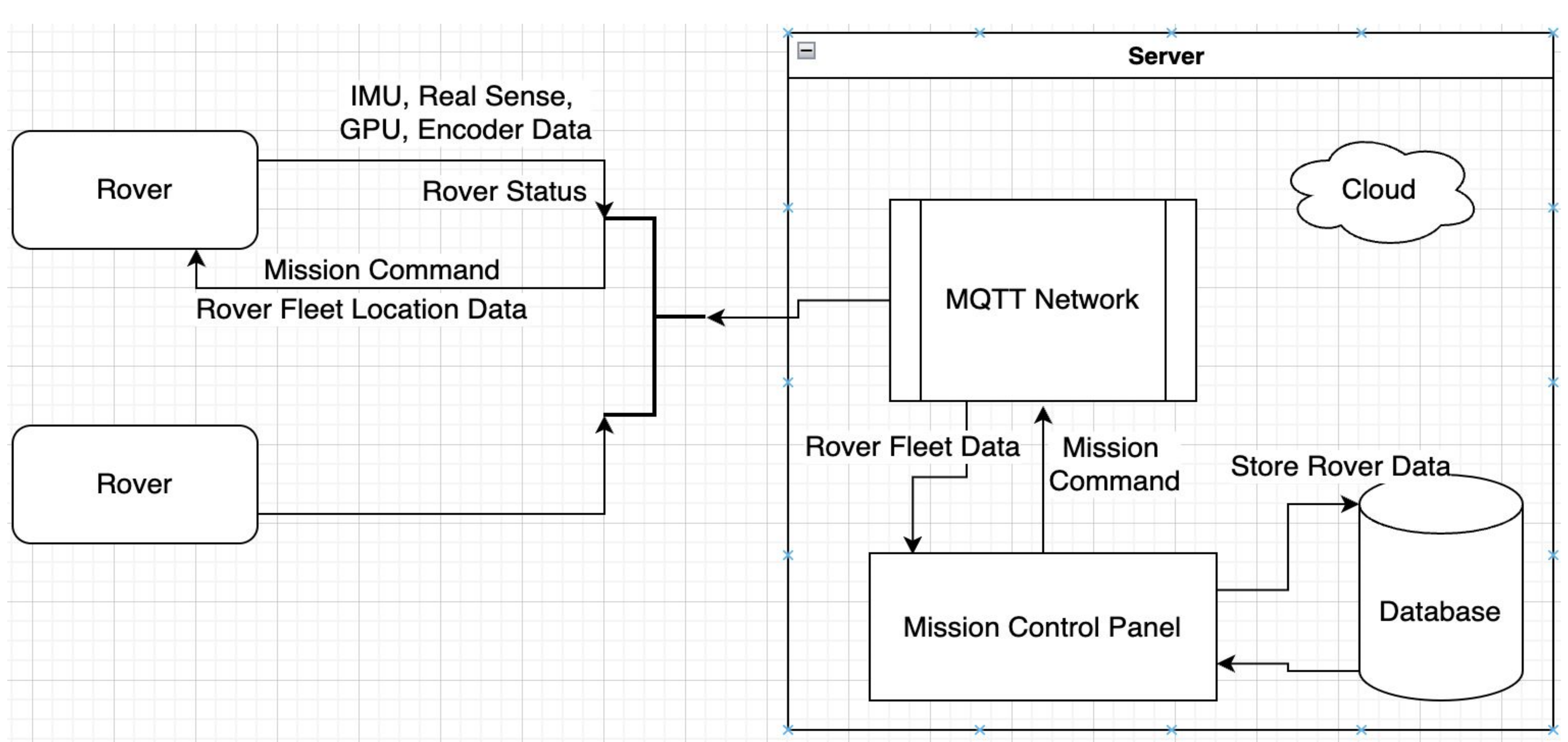
- Establish electronics communication capabilities, ensure power and safety to multiple subsystems.



- Hardware level Sensor Fusion: bringing in multiple sensor data into a single board computer. It manages data traffic, and provide post-data processing capabilities.
  - Manages board level communication protocols: UART / I2C / USB

Server/Intercommunication

- Enable fast, low latency communication between multiple rovers and command terminal via a MQTT network
- Real time data transfer allows complex calculations and algorithms to be done on cloud

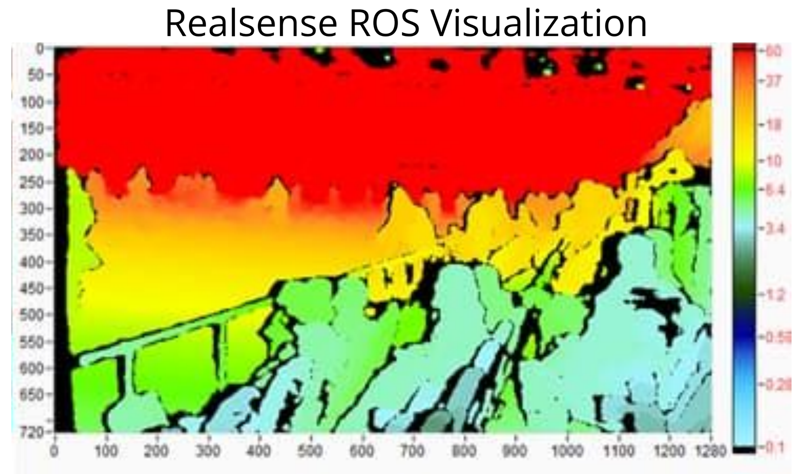


Testing & Validation

- Logic Analyzer, also known as digital oscilloscope, is critical to analyzing waveform in serial communications. The waveform below demonstrates testing the I2C communication from RoboClaw, which allows us to root cause failures from one electronics at a time.

- Sensors are tested individually using ROS visualizations using a testbench board and NANO before being integrated into the robot

Realsense ROS Visualization



Conclusion & Future Improvements

- In this project we accomplished:
  - Sensor fusion of the IMU, Realsense, GPS, and wheel encoders
  - Integration with server to receive sensor data and understand robot behavior and dynamics
  - Demonstrates remote control / telemetry abilities via Server
- Future improvement:
  - Extend the intercommunication capabilities to perform cooperative movements among 2+ robots.
  - Incorporate GPS module to the system to ensure ground true, and extend navigation capabilities.
  - Building additional rovers to showcase multi-robot communication to more efficiently map out surroundings
  - Integrating shared-mapping algorithm to enable cooperative exploration

References and Acknowledgments

Industry Mentors: Andrew Gray, Jonathan Sauders, Jacqueline Sly, Jean-Pierre de la Croix
Faculty Mentor: Ken Eguro

https://github.com/nasa-jpl/open-source-rover
https://github.com/sonyccd/roboclaw_ros

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