LUNAR COOPERATIVE AUTONOMOUS DISTRIBUTED ROBOT EXPLORERS (CADRE)

STUDENTS: ZUHAIR LATEEF, TAO JIN, JIARONG QIAN, NATHAN NESS

13

Abstract

The Lunar CADRE system develops a geological map of the lunar surface and conducts a variety of scientific measurements at different locations. Tasks are coordinated within a swarm of robots to improve efficiency and help overcome physical barriers. We were challenged with developing the mapping algorithm, dividing tasks between robots, and implementing the sensor payload.

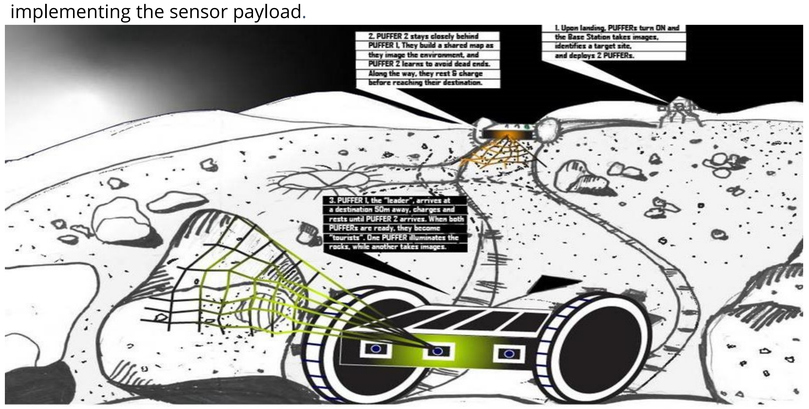

Figure 1. Robots coordinating tasks and reporting map data back to Base Station

Software Requirements

- Develop algorithm for dividing tasks between robots and coordinating movement
- Collect data for 3D map using Zed Mini Camera, and stitch map together from combined robot data
- Sample sensors at reasonable rate and correlate with location on 3D map
- Autonomously operate sensor payload
- Use ROS to control robot movements, integrate sensors, and publish odometry data

Hardware Requirements

- Find types of measurements that can and should be measured on the lunar surface and decide which sensors can be used
- Communicate with sensor manufacturers to produce sensors with desired dimensions and sensitivity
- Integrate sensors with NVIDIA Jetson Nano to process data and combine with 3D map
- Utilize input from Zed Mini Camera accelerometers and wheel encoders to publish velocity and acceleration data

System Overview

Each robot gathers input data from their sensors, Zed Mini Camera, and wheel encoders. Using this data, each robot generates a localized map with marked sites where scientific measurements were conducted. Each robot reports their map and sensor data to the base station where it is combined to form a single data structure. Using this information, the base station assigns blanks regions of the map for each robot to explore, and the data collection continues.

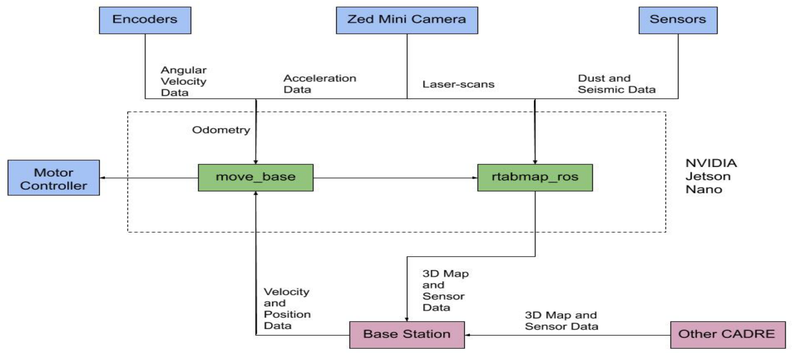

Figure 2. Block diagram of CADRE system

3D Mapping and Environment Navigation

- Combines odometry data from move_base and laser scan data from Zed Mini Camera to gain information about surroundings in real time using 3D SLAM
- Uses ROS rtabmap_ros [1] (Real Time Appearance Based) package which generates 3D point clouds of the environment and creates a 2D occupancy grid for navigation
- Map is incrementally built and optimized when a loop closure is detected (vehicle returns to previously visited location)
- Takes data from all 3 robots and stitches together unified map
- Uses NVIDIA Jetson Nano for high speed and high accuracy image processing

Sensor Integration

- Dust Accumulation
  - ❖ Integrated solar panels on robots and measured output voltage as a proportion of peak voltage
  - ❖ Tested by placing variable amounts of dirt on solar panel and checking measurements
- Seismic Wave Detection
  - ❖ Uses triangulation algorithm to calculate source of seismic wave based on accelerometer triggering order
  - ❖ Tested by creating an impulse near a robot and checking if robot detected impulse and found direction of epicenter
- Initially planned on testing radiation sensor using radioactive materials from UW Geology Department. Due to COVID-19, testing was no longer possible

Robot Movement and Odometry

- Controls robot velocity and publishes robot odometry data
- Reads angular velocity data from wheel encoders and acceleration data from accelerometers onboard the Zed Mini Camera
- Utilized ROS move_base package [2] for Navigation Stack
- Initially intended to install accelerometers in "tail" of robots, but were unable to 3D print a modified structure that could house the desired accelerometers

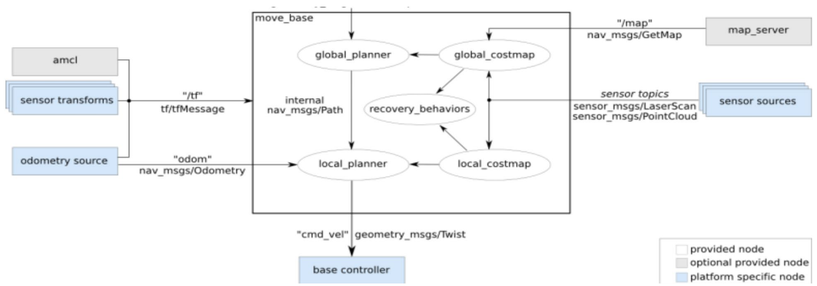

Figure 4. Block diagram of move_base package [2]

Future Work and References

- Synchronize mapping with scientific measurements to show where samples were collected
- Add more sensors for other types of measurements

[1] "rtabmap_ros - ROS Wiki," *ros.org*. [Online]. Available: http://wiki.ros.org/rtabmap_ros. [Accessed: 26-May-2020].
[2] "move_base - ROS Wiki," *ros.org*. [Online]. Available: http://wiki.ros.org/move_base. [Accessed: 26-May-2020].
[3] "Visualization with Python¶," *Matplotlib*. [Online]. Available: https://matplotlib.org/. [Accessed: 26-May-2020].

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

FACULTY ADVISOR: HOWARD CHIZECK
INDUSTRY MENTORS: SARAH HOVSEPIAN, ERIK JUNKINS, WAYNE ZIMMERMAN, ALESSANDRO BUSCICCHIO
SPONSOR: NASA JET PROPULSION LABORATORY