Individual Lab Report - 09

Lunar ROADSTER

Team I

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1 Individual Progress

1.1 Global Navigation Planner

The global planner is responsible for planning a path to every crater by following a smooth spline that sticks to the latitude on which the craters lie. The code development for this is complete and the same was also tested and tuned by deploying it on the rover.

1.1.1 Feature Development

Previously, the code only contained visualizations of the smooth spline that fits the gradable craters and also the planned path. Now I added visualizations to show the selection of the gradable and ungradable (or obstacle) craters as well. Figure 1 shows this, with the green circles showing the gradable craters and the red representing the obstacle which we would like to avoid. The blue circle in the same picture shows the latitude on which all the craters lie.

Apart from this, the visualizations also show the spline that fits all the gradable craters, the movement of the robot as well as the final planned path. This is shown in Figure 2.

Apart from this, I also added deviation statistics like the cumulative, mean, rms, max deviations, and total path length. This will be used to prove our performance metrics during FVD.

Finally, the entire code has been converted into a ROS Service, and will be easily integrated into the Behavior Executive Node.

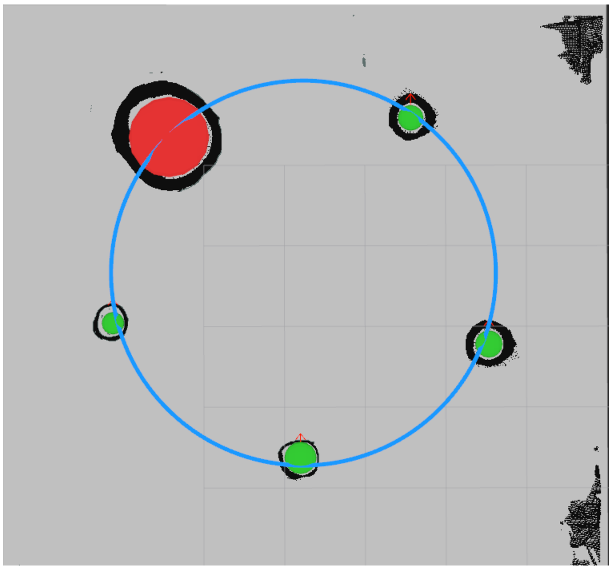

Figure 1: Global Navigation Planner showing gradable (green) and ungradable (red) craters along with the latitude (blue)

1.1.2 Testing and Tuning

The global navigation planner was not only tested in simulation, but we also deployed it on the rover. The planner uses the localization information to find the current rover position in the map. Then it feeds in the crater centroids one by one as the target pose and plans a path to each. I had to tune some hyperparameters to ensure a proper planned path and the tuning is now complete. The global navigation controller will then use the planned path to execute motion and move to the crater.

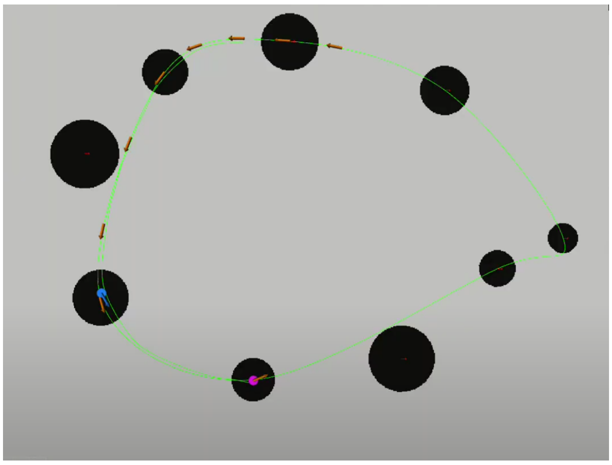

Figure 2: Global Navigation Planner showing the smooth spline and planned path

1.2 Global Navigation Controller

The global navigation controller is the pure pursuit controller. I worked in collaboration with Simson on this. We faced quite a few issues with getting it working at the beginning. Once we had it running, there were issues with the curvature and some hyperparameter tuning. We fixed all of them by testing and everything works reliably now. We conducted multiple accuracy tests in which we gave the rover certain crater centroids as goals and observed that the rover accurately moved towards them. Figure 3 shows the controller in action as it accurately reaches a crater centroid.

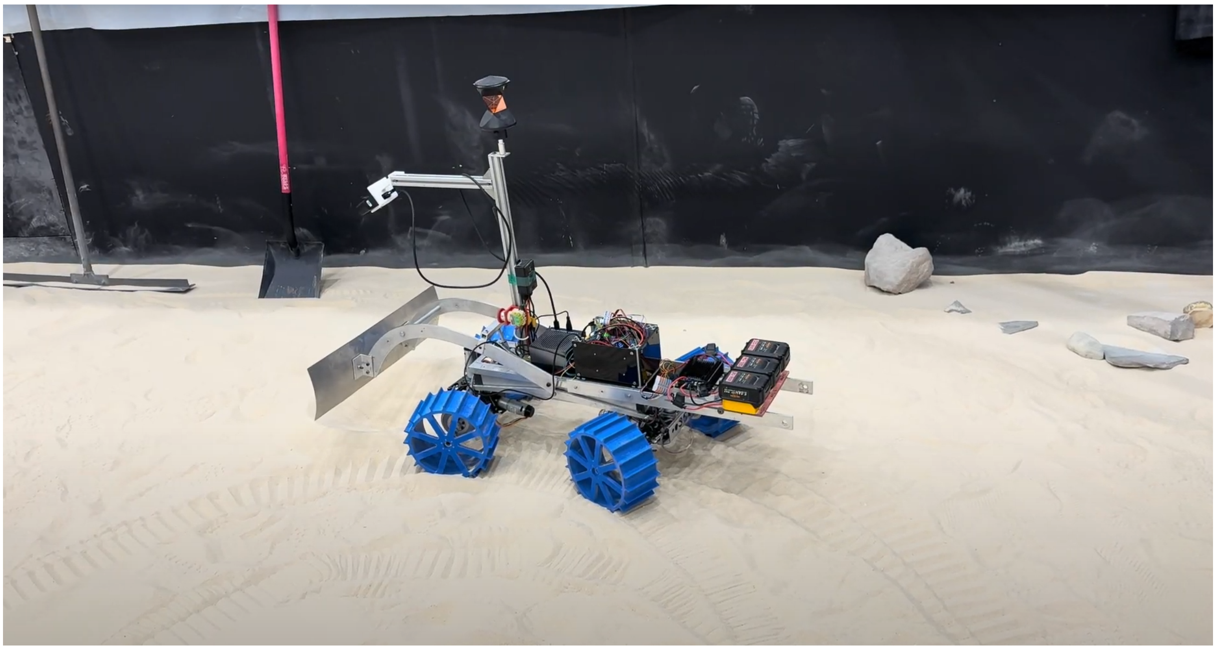

Figure 3: Global Navigation Controller in action

1.3 Teleoperation Issues

While my other teammates were conducting some tests of their own, they faced issues with the teleoperation not working. There were some Micro-ROS issues that came up due to installing some other packages and I fixed all of them. I speculate that such issues will not occur again.

2 Challenges

The challenge that I faced was with the tuning. It required conducting multiple experiments and debugging. While testing the navigation controller, we found that the steering was slipping too much and hence could not turn properly. Ankit fixed this by changing the orientation of the steer motors and moving the pinion closer so that it meshes much better with the rack. This completely fixed our steering problems and the rover now turns extremely well.

3 Team Work

- **Bhaswanth Ayapilla:** My primary work involved working on the navigation stack. The global planner has been tested and tuned on the final map of the environment and deployed on the rover. I worked with Simson in the global navigation controller. We collectively tested and tuned the complete navigation stack, along with William's help. I helped Ankit and Deepam by fixing teleoperation issues. Ankit and Simson helped in fixing the steer issues, which was crucial for navigation. I worked with Ankit and Deepam ideate how the planning stack will be used by the navigation stack. Finally, I worked with the entire team to finalize the Behaviour Executive Node for complete integration.

- **Ankit Aggarwal:** Ankit primarily focused on parsing robot poses using crater geometry from Perception and integrating it with the previous planning methodology. He worked with Deepam and me to ideate how the navigation stack will use the robot poses for manipulation and debugging teleoperation issues. He worked with Simson to fix the ongoing steering slip issue. Deepam and him also worked with William to finalize how the validation and perception stacks will interact. Finally, he worked with the whole team to finalize the Behaviour Executive Node for complete subsystem integrations.

- **Deepam Ameria:** Deepam work since last PR was focused on implementing the Perception Stack online on the Jetson Orin. He ported the code to the Orin, and implemented confidence threshold for robust detections. He used camera intrinsics to determine the centroid of the crater, and the bounding box edges to determine the crater diameter. These values will be published on a topic, and can be used by the planning stack to plan robot poses for the mission. Deepam also worked with Ankit and me to ideate how the planning stack will be used by the navigation stack. Deepam also took ownership of the Standards and Regulations task, researching and compiling information and the application of the standards chosen by the team. He collaborated with the entire team to finalize the workflow of the Behaviour Executive Node, which is crucial for the integration of all the subsystems.

- **Simson D'Souza:** Simson primarily focused on the navigation stack and the generation of the final global costmap. The global navigation controller was modified to enhance navigation performance. Simson and I collaborated on tuning the navigation stack to improve overall accuracy. Additionally, Ankit and him worked together to resolve the steering slippage issue. As a team, we also collaborated on planning the workflow for the Behavior Executive Node, which was crucial for integrating the various modules and addressing potential integration issues in advance.

- **Boxiang (William) Fu:** William's work since the last progress review focused on revamping the validation unit and Skycam localization unit. The validation unit was revamped to remove the dependence on discretizing the point cloud to a grid map. Instead, the relative positions of the points is used to calculate gradients using surface normals at each point relative to their K-nearest neighbors. William also collaborated with Deepam and Ankit to solicit their requests for the output of the validation unit to give to the perception/planning unit. William also revamped the Skycam localization unit so that a classical computer vision technique is used rather than a neural network. This was done to improve the localization accuracy. William collaborated with Bhaswanth and Simson to obtain their requirements for localization accuracy.

4 Plans

The following are my goals for progress review 11:

1. More testing and tuning of the navigation stack
2. Obtain deviation statistics to prove performance metrics related to navigation
3. Work on integrating everything into the Behavior Executive Node
4. Quality assurance of hardware
5. Quality assurance of navigation
6. Quality assurance of localization
7. Dress rehearsal for FVD