



Lunar ROADSTER

(Robotic Operator for Autonomous Development of
Surface Trails and Exploration Routes)

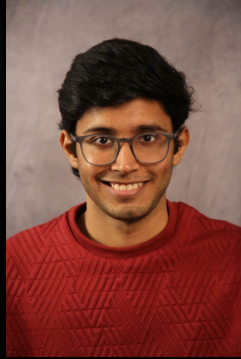
“Starting with a foothold on the Moon, we pave the way to the cosmos”



The Team



Ankit Aggarwal



Deepam Ameria



Bhaswanth Ayapilla



Simson D'Souza



Boxiang (William) Fu



Dr. William "Red" Whittaker

Agenda

1. Validation: Tuning, testing and integration
2. Perception: Geometric feature extraction, online implementation
3. Navigation: Test and tune the global planners and controllers on the rover
4. Planning: Parsing robot poses and integrating perception, validation, and navigation
5. Localization: Implement SkyCam methodology

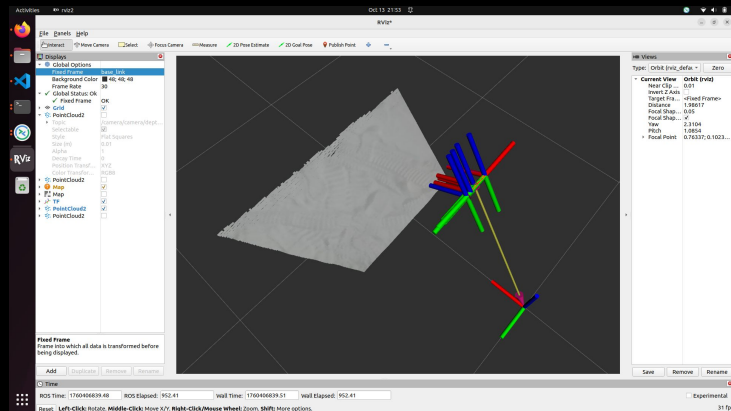
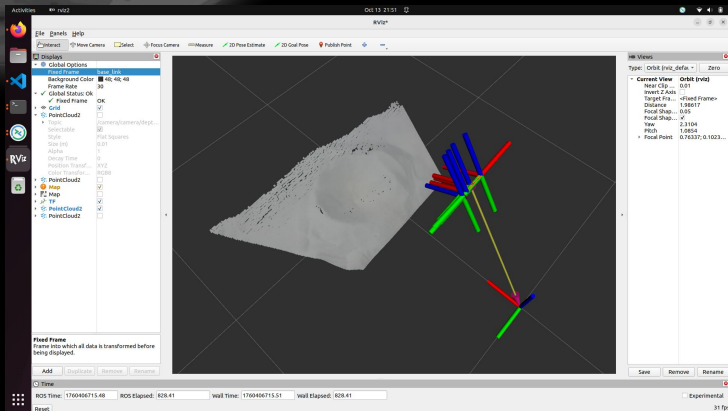


PR10 Code Development Deadline

Goal: Validation Stack

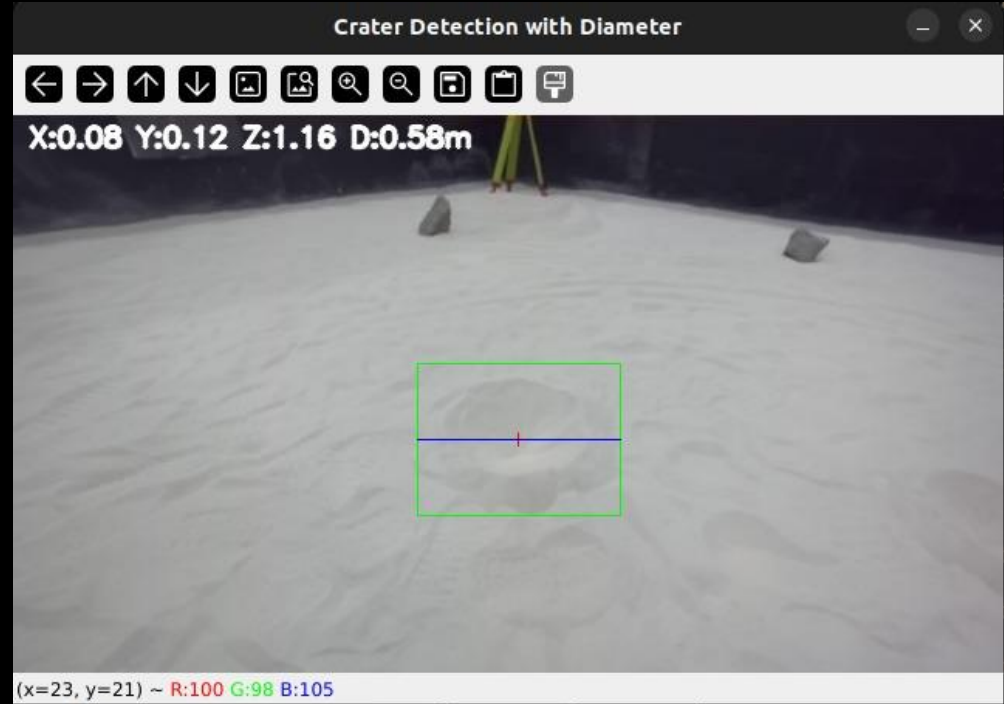
Implementation:

- Obtains most recent point cloud feed from the ZED camera
- Voxel downsampling, and builds a KdTree
- Surface normal estimation and calculate per-point slope from the vertical z-axis
- Nearest neighbor smoothing and masking to filter out phantom points and walls/edges
- Compute aggregate slope statistics over several frames

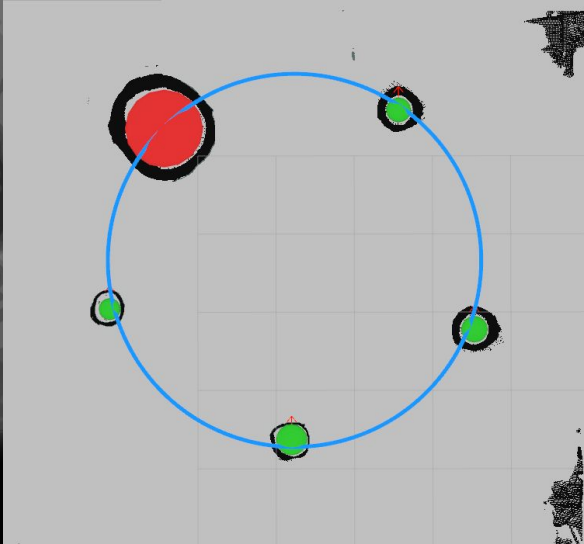


Goal: Perception Stack

- Online implementation on Orin - **DONE**
- Crater Center Coordinates in Camera Frame (X,Y,Z)- **DONE**
 - Transform to static world frame - **IN PROGRESS**
- Crater Diameter (in meters)- **DONE**



Goal: Navigation stack



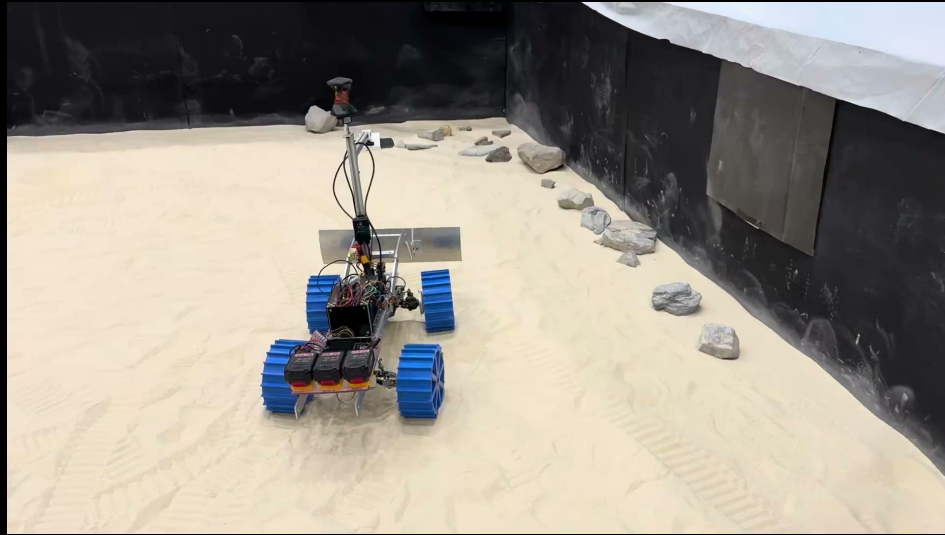
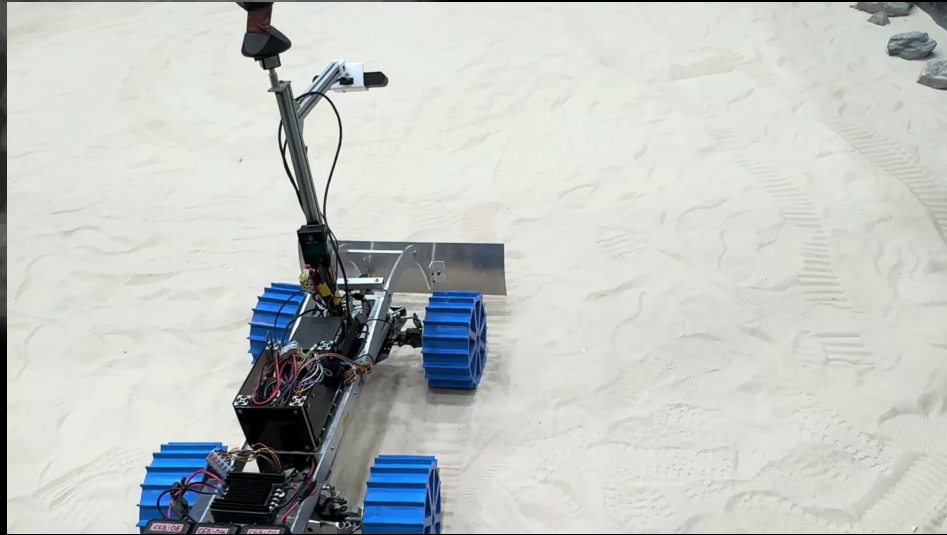
- Global Planner tested and tuned
- Visualization shows gradable and ungradable craters
- Converted into ROS Service
- Blue line shows latitude
- Green line shows planned path
- Deviation statistics are calculated

```
[INFO] [1759973329.372613491] [map_1ol]: origin[0]: 0
[INFO] [1759973329.372619282] [map_1ol]: origin[1]: 0
[INFO] [1759973329.372623348] [map_1ol]: origin[2]: 0
[INFO] [1759973329.372625888] [map_1ol]: free_thresh: 0.196
[INFO] [1759973329.372631907] [map_1ol]: occupied_thresh: 0.65
[INFO] [1759973329.372637267] [map_1ol]: mode: trinary
[INFO] [1759973329.372642447] [map_1ol]: negate: 0
[INFO] [1759973329.372633388] [map_1ol]: Loading Image file: /home/bhaswanth_a/Lunar-ROADSTER/lr_ws/src/navigation/maps/crater_ring_map.pgm
[INFO] [1759973329.410508479] [map_1ol]: Read map /home/bhaswanth_a/Lunar-ROADSTER/lr_ws/src/navigation/maps/crater_ring_map.pgm: 800 X 800 map @ 0.05 m/cell

6: rviz2 ~~~~~
[INFO] [1759973216.692913677] [rviz2]: Setting goal pose: Frame:map, Position(33.5557, 22.2384, 0), Orientation(0, 0, 0.86741, 0.49748) = Angle: 2.10019
[INFO] [1759973272.163338474] [rviz2]: Trying to create a map of size 800 x 800 using 1 swatch s
[INFO] [1759973276.644475502] [rviz2]: Setting goal pose: Frame:map, Position(34.0738, 22.2384, 0), Orientation(0, 0, 0.875753, 0.482759) = Angle: 2.13399
[INFO] [1759973292.18389853] [rviz2]: Setting goal pose: Frame:map, Position(27.9954, 14.2866, 0), Orientation(0, 0, 0.482656, 0.979269) = Angle: 0.408547
[INFO] [1759973305.047258189] [rviz2]: Setting goal pose: Frame:map, Position(21.1367, 11.0696, 0), Orientation(0, 0, 0.16318, 0.986596) = Angle: 0.327826

z: bhaswanth_a@Bhaswanth-Legion-~$ cd Lunar-ROADSTER/lr_ws
Transitoning successful
~/Lunar-ROADSTER/lr_ws | devel-namespace-bhaswanth | 17.76 | roslifecycle set map_server activate
Transitoning successful
~/Lunar-ROADSTER/lr_ws | devel-namespace-bhaswanth | 17.76 | roslifecycle set map_server configure
Transitoning successful
~/Lunar-ROADSTER/lr_ws | devel-namespace-bhaswanth | 17.76 | roslifecycle set map_server configure y=1
^([ATransitoning successful
~/Lunar-ROADSTER/lr_ws | devel-namespace-bhaswanth | 17.76 | roslifecycle set map_server activate
Transitoning successful
~/Lunar-ROADSTER/lr_ws | devel-namespace-bhaswanth | 17.76 | roslifecycle set map_server configure
Transitoning successful
~/Lunar-ROADSTER/lr_ws | devel-namespace-bhaswanth | 17.76 | roslifecycle set map_server activate
[WARN] [1759973311.588942152] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973311.788857517] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973311.988855982] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973312.188861668] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973312.388815054] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973312.588830799] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973312.788826665] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973312.988833855] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973313.188911626] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973313.388921959] [global_astar_planner]: Robot pose unavailable ...
[INFO] [1759973313.588991220] [global_astar_planner]: map loaded=1, craters_loaded=1, ring_read
[WARN] [1759973313.589088839] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973313.788888619] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973313.988945150] [global_astar_planner]: Robot pose unavailable ...
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[WARN] [1759973314.988997136] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973315.188963277] [global_astar_planner]: Robot pose unavailable ...
[WARN] [1759973315.388972732] [global_astar_planner]: Robot pose unavailable ...
^C[INFO] [1759973315.430233599] [roscpp]: signal handler(signum=2)
~/Lunar-ROADSTER/lr_ws | devel-namespace-bhaswanth | 17.76 | roslifecycle global_astar_node -ros-args -p crater_threshold:=3.9 -p max_expansions:=5000000 -p obstacle_weight:=0.0 -p rlin g bias_k:=0.2 -p align_k:=0.2]
```


Goal: Navigation stack



Global Controller tested and tuned

Goal: Planning Stack - now merged with Perception

Robot pose parsing complete (ROS Service)

- a. Obtains crater geometry from perception (integrated)
- b. Creates source, sink and offset poses for manipulation
- c. All hyperparameters are in yaml files
- d. Code developed with BEN in mind and will be easily integrated
- e. Validation will be integrated into BEN directly.
- f. **Next step** - testing and tuning parameters

Goal: Sky Cam Localization

Implementation:

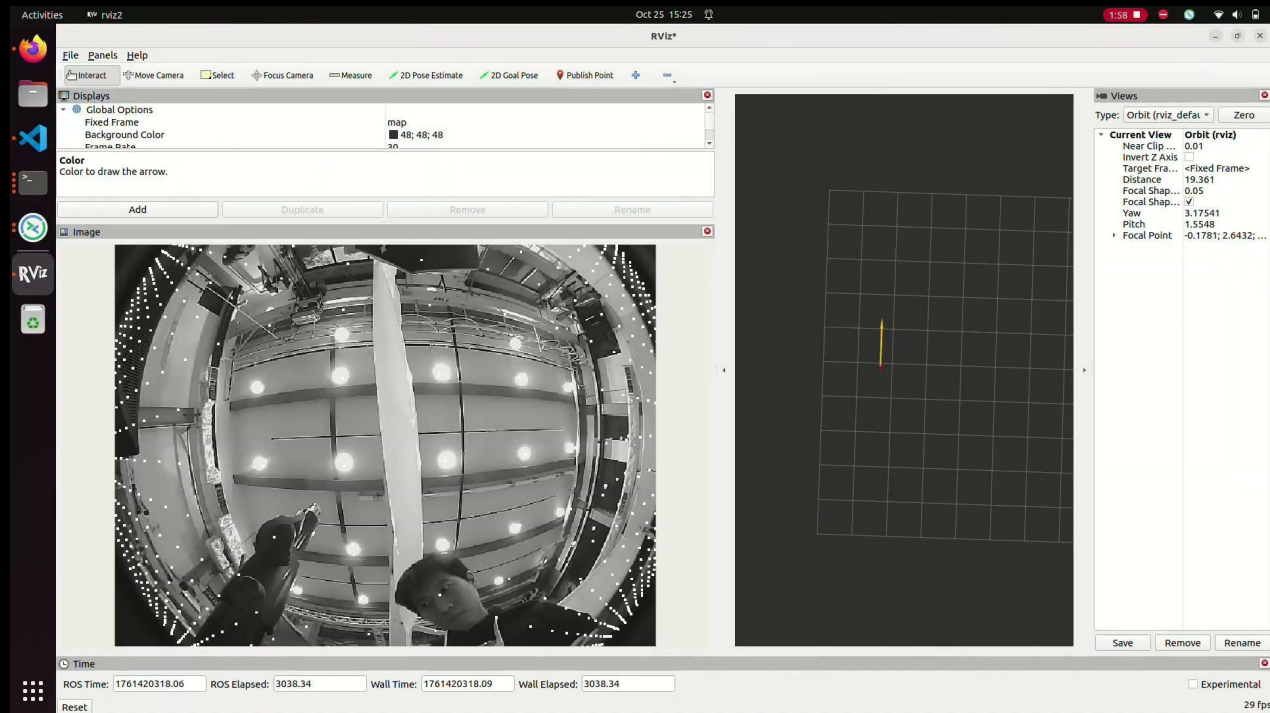
- Detects ceiling light pattern using fisheye camera
- Filters “of interest” pixels by brightness
- Levenberg–Marquardt optimization to fit ceiling grid
- Convert camera 2D coordinates to 3D coordinates using ceiling height



Skycam Estimate



Ground Truth



Issues:

- Roll and pitch causes pose to drift, trying mechanical gimbal and software fixes

Risk Management

Risk ID	Risk Title	Risk Owner	Risk Type:	Logistics																																				
R30	No spares available	Team	<div><div>Likelihood</div><div><table><tr><td>5</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>4</td><td></td><td></td><td></td><td></td><td>⊗</td></tr><tr><td>3</td><td></td><td></td><td></td><td></td><td>⊕</td></tr><tr><td>2</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>1</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr></table></div><div>Consequence</div></div>	5						4					⊗	3					⊕	2						1							1	2	3	4	5	
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4						⊗																																		
3						⊕																																		
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1																																								
	1	2		3	4	5																																		
Description		Date Added																																						
Discontinued model, spare parts unavailable		3/4/2025																																						
		Date Updated																																						
		8/30/2025																																						
Consequence																																								
The whole project falling through, or redo almost all subsystems on a different rover.																																								
Action/Milestone		Success Criteria	Date Planned	Date Implemented																																				
Check out eBay and other similar platforms for spares		Successfully find exact spares on these platforms	3/6/2025	9/22/2025																																				
Check out and stock similar parts if not same		Successfully find and stock similar parts	3/6/2025	9/22/2025																																				
Find a twin rover that was used by a previous team on campus		Successfully find the twin rover and scavenge parts	3/6/2025	3/7/2025																																				
Find similar parts - a slightly smaller pinion and motor set		Spares problem will be solved	9/10/2025	9/22/2025																																				

Risk Management

Risk ID	Risk Title	Risk Owner	Risk Type: Logistics	
R36	PRL Moonyard Access	William		
Description		Date Added		
Securing Moonyard access for testing/demos will be restricted and challenging		8/29/2025		
		Date Updated		
		8/29/2025		
Consequence				
No testbed available for testing and/or FVD				
Action/Milestone	Success Criteria	Date Planned	Date Implemented	
Devise and discuss a testing and demo plan with Prof. Red and Prof. David Wettergreen beforehand and reserve slots	Successfully meet and discuss the schedule of high priority projects	9/11/2025	9/11/2025	
Complete Medical Evaluation to get unrestricted but controlled access	Successfully complete the Medical Evaluation and get unrestricted access to the Moonyard	9/5/2025	9/11/2025	
Respirator Training	Complete training and get custom masks	9/30/2025		

Risk Management

Risk ID	Risk Title	Risk Owner	Risk Type:	Technical
R34	Arduino requires reset before operation	Bhaswanth	<div><div>Likelihood</div><div><div><div></div><div></div><div></div><div>⊗</div><div></div></div><div><div></div><div></div><div></div><div></div><div></div></div><div><div></div><div>⊕</div><div></div><div></div><div></div></div><div><div></div><div></div><div></div><div></div><div></div></div></div><div><div>5</div><div>4</div><div>3</div><div>2</div><div>1</div></div><div><div>1</div><div>2</div><div>3</div><div>4</div><div>5</div></div><div>Consequence</div></div>	
Description		Date Added		
Arduino needs to be manually reset each time before starting autonomy or switching between autonomy and teleoperation modes.		3/4/2025		
		Date Updated		
		4/10/2025		
Consequence				
Slows down setup time and impacts operational readiness, delaying mission start and mode transitions.				
Action/Milestone		Success Criteria	Date Planned	Date Implemented
Check USB port permissions and drivers issues on Jetson		Successfully establish consistent serial connection without reset	4/26/2025	9/5/2025
Verify that Arduino is connected via USB 3.0 instead of USB 2.0 port		Ensure stable high-speed communication	4/26/2025	9/5/2025
Check for ROS node frequency mismatches causing packet loss to Arduino		Match ROS publish/subscribe rates	4/26/2025	9/5/2025
Implement a software reset trigger		Reset can be called from the operations terminal	9/7/2025	

Issues Log

I14	09/14/2025		Team	Steer pinion tooth chipped and worn-out due to wear-and-tear. Unable to find exact replacement for the pinion	1. Replace with similar pinion that has different tooth count 2. Switch to using another chassis		
I15	09/14/2025	10/07/2025	Ankit Aggarwal Deepam Ameria Simson D'Souza	Wires keep on coming loose during operations due to bad soldering	1. Re-solder every wire 2. Switch to plug connectors and buy adaptors for the RoboClaws and motors	Switched wiring to use plug connectors	This allows us to stop worrying about loose wiring due to bad soldering
I16	10/04/2025		Team	Unable to obtain rear steer motor encoder feedback	1. Recheck wiring permutations to see which one is correct 2. Retrace wiring to make sure everything is wired correctly		
I17	10/04/2025		Team	Front steer has power issue	1. Recheck front steer power connections with the RoboClaw connectors 2. Check how the rear steer power connections are connected and try to copy		

Future Work

PR 11 Goals:

- Localization QA & compensation for roll and pitch
- Validation QA & integration with BEN stack
- Navigation QA
- Planning QA
- Perception QA
- Hardware QA



THANKS!

Team Lunar ROADSTER

