LunarVLA: Adapting and Deploying a Navigation Model for Lunar Rovers

Trevor Slack, Staff Autonomy Engineer (trevor.slack@lunaroutpost.com)

Company Background:

Lunar Outpost is an industry leader in lunar surface mobility, commercial space robotics, and space resources. The company develops robotic platforms and autonomy technologies intended to expand sustained exploration and operations on the lunar surface and in challenging terrestrial environments.

Lunar Outpost's exploration-class Mobile Autonomous Prospecting Platform (MAPP) and human-rated Lunar Terrain Vehicle (LTV) work reflect a broader portfolio spanning commercial, civil, and defense programs. With over a dozen active contracts across commercial, defense and civil space, Lunar Outpost is The Next Leap that will enable humanity to become interplanetary.

Description of Work to Be Done:

Frontier robotics systems increasingly apply techniques developed for large language models and multimodal transformers. Vision-Language-Action (VLA) models extend these ideas to robotics by mapping visual observations, natural-language instructions, and robot state into navigation or manipulation actions. These models are promising for open-world autonomy, but they remain sensitive to domain shift, robot embodiment differences, and the gap between pretrained data and mission-specific operating conditions.

For this project, the Field Session team will investigate whether refinement can improve an open-source navigation VLA model for a simulated lunar environment.

Students will focus their efforts on four specific areas:

1. **Model and Data Interface:** Understand open-source VLA libraries and their interfaces. Implement a reliable adapter between the provided simulation environment and the selected model. Produce an Interface Control Document (ICD) and Software User Guide (SUG).
2. **Dataset Generation and Validation:** Collect simulated rover trajectories to create training and validation datasets.
3. **Parameter-Efficient Refinement:** Establish zero-shot performance and then refine selected model components.
4. **Closed-Loop Deployment and Evaluation:** Deploy the refined model in simulation. Compare the refined model with the unmodified model. Analyze success, collisions, path efficiency, latency, and generalization.

Expected Deliverables

- A reproducible development environment and documented setup procedure.

- A simulator to open-source VLA adapter with unit tests.
- A documented lunar simulation dataset with instructions for deterministic data generation.
- Baseline results for the unmodified model.
- At least one refined model.
- Closed-loop evaluation across differing scenarios.
- A technical report describing methods, assumptions, results, failure modes, and recommended next steps.
- A final demonstration showing a refined policy navigating the simulation environment.

Minimum Success Criteria

1. Run the open-source VLA in simulation.
2. Generate and validate a dataset.
3. Train at least one refined model.
4. Deploy the resulting model in closed-loop simulation.
5. Compare the refined model against the unmodified model using defined quantitative metrics.
6. Deliver documented source code, model configurations, evaluation results, and reproducible step instructions.

Desired Skills for Students

- Python software development, debugging, unit testing, and Git-based version control.
- Coursework or interest in machine learning, deep learning, computer vision, or robotics.
- Familiarity with PyTorch, Linux, NumPy, and basic linear algebra is helpful.
- Experience with simulation (MuJoCo), vehicle navigation, or GPU computing is beneficial but not required.
- Ability to communicate technical results, document assumptions, and work effectively in an iterative team environment.

We understand that not every student will enter the project with every desired technical skill. Students who can problem solve, communicate effectively, and learn independently can excel with mentorship from Lunar Outpost engineers.

Preferred Team Size: 3-4 students

Given the scope of this project a group of 3-4 students is preferred but 2 students could also excel given they are willing to problem solve and learn.

Internships at the End of the Course

Lunar Outpost is happy to consider offering internships to strong project participants at the end of the course.

Location Where Work Would Be Performed

The project can be performed primarily on campus or remotely using the provided development environment. Students may also meet with engineers or gain access to additional GPU resources at Lunar Outpost's Arvada, Colorado office, which is a short drive from the Colorado School of Mines campus.

Confidentiality and Intellectual Property

This project may involve Lunar Outpost proprietary information, software interfaces, simulation assets, and technical data. All participating students will therefore be required to sign a non-disclosure agreement before receiving access to project resources. Lunar Outpost will retain ownership of all project data and intellectual property developed through the project, including source code, trained models, datasets, documentation, results, and related artifacts.

Students will work at the intersection of multimodal AI, lunar robotics, and space exploration. We're excited to collaborate with the next class of lunar engineers!