Rovers

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***Abstract*—Begin the design and construction of a mock rover. A rover would be an area of space exploration completely new to SPEX, because of this there are a lot of unknowns that need to be answered before starting this project. Because of this the project will require a large amount of prototyping and testing. The team would look at the talent and skills of RIT Space Exploration and answer the question: what caliber of rover are we able to make. It would employ a multidisciplinary team for construction and development. The project would be slated to run for two semesters. The rover would be extremely promotable and would look great at Imagine RIT.**

I. Introduction

Robotics and by extension rovers are a tremendously important part of space exploration. This is also an area that RIT Space Exploration has very little experience with project-wise. The purpose of this project is to assess and assert the capability of RIT SPEX in regard to the construction and fabrication of a mock-rover and then begin construction. As this is a new area to RIT SPEX, prototyping and experimenting is necessary to most effectively accomplish this goal. This project will look at the unknowns, technical challenges, project management, and member skills of RIT Space Exploration in regards to a University Rover Competition (URC) capable rover. The URC is hosted by The Mars Society annually. It is very competitive and requires a very complex and expensive rover that is currently out of scope for SPEX. This rover would need to be capible of full autonomous navigation, soil collection and analysis, and precice robotics. This project is the first step in building the skills for such a team.

II. Primary Objective

The goal of this project is deliver a functioning mock rover. We define mock rover as a functioning rover built to specifications for a mock mission as it will not be launched. The rover will allow the team to develop skills and knowledge to build a more feature completer rover in the future. These skills include rover fabrication and design, autonomous navigation, electrical system design, rover testing, computer vision, and robotics. The rover will be testing using events designed similar to th URC but scaled down to fit the scope of this rover. We will be using time as a metric as well as binary metrics for completion of the parts of the competition. This includes 'does the rocker-bogie system work as intended', 'will the rover stop when directed at an obstacle', etc. The details are defined in the minimum viable product section.

III. Secondary Objectives

The study will also investigate the University Rover Competition (URC) as hosted by the Mars Society as a potential long term goal. The team will accomplish this by evaluating how many of the MVP improvements are accomplished. If none of these improvements are not able to be implemented then the team is not near URC ready. The competition is held annually and features four very intense competitions. Such a rover would need to be fully self navigating, perform scientific analysis on soil samples, and having a robotic arm capable of fine motor control. Such a project would be among the most ambitious SPEX has ever attempted. The skills learned from this project should be applicable to such a future project. This secondary objective is directly related to the long term vision of the rovers project.

IV. Minimum Viable Product

The minimum viable product (MVP) has been defined by the basics of what can be called a 'functioning rover'. This includes features like suspension, motors, power and controls. The MVP is defined by the following features:

- Rocker-bogie-like suspension
- Ability to control remotely (such as a gamepad)
- Ability to traverse terrain such as gravel, cement, and asphalt
- Technical report on GitHub as deliverable
- Rover software on GitHub as deliverable
- Rover hardware as deliverable
- Rover project present at Imagine RIT

The MVP is intended to be flexible in implementation depending on funding. The size and materials are not defined because of this. Should the funding allow for it there are many improvements that can be made beyond the MVP.

- Lidar based CV for autonomous or partially autonomous navigation
- Improved navigation with use of GPS system
- Robotic arm with 3+ degrees of freedom
- Drill or grasper attachment
- Soil sample analysis with Archimedes' screw
- Larger and or faster rover that is able to traverse obstacles of greater magnitude or hold more scientific equiptment.
- Solar cells for additional long-term viability
- Web control interface with GUI
- Durable construction with carbon fiber or similar materials

V. Benefit to SPEX

Rovers are a huge part of space exploration. It is also an area that SPEX is not currently involved with. It would be beneficial to our members to get some experience in this area. A rover would look super good for SPEX at Imagine RIT. The rover would be rather large and would attract many eyes. We could even demo it outside if there is sufficient space. A rover would be very easy to get video and photos of for SPEX promotions. Having a rover is also another opportunity for SPEX to fundraise. There is plenty of space to place company logos on the body of the rover. It would also allow for SPEX to reach out to robotics companies.

1) Computer Science: The potential self-driving component would be the heaviest computer science project SPEX would have attempted, this would help with retention of CS and SE majors. Some of the potential self-driving features could be implemented with artificial intelligence. Machine learning and artificial intelligence are at the forefront of computer science right now. They are heavily desired in industry including space exploration.

A. Mindset

The purpose of this project is to investigate and implement a mock rover. Because of this the team members must be in the mindset to analyze each part of the project and identify as many problem areas that need answers as possible. This means being specific on how we are going to accomplish our goals. What material, what algorithm, with what method will we be accomplishing this. It is very easy to over estimate the team's ability especially when the project is so new to the team.

B. Traceability

It is important that the team members document the sources they use to gather information. There will be a Google Drive folder that will hold notes with links to any books, articles, media or their sources that are relevant to the rover project. The software and hardware will be tracked on GitHub. This includes the technical report.

C. Assessing Technical Skills

Building a rover, especially one built to URC specifications requires a large team with a diverse set of technical skills. This project will require SPEX to look at and asses what areas are sufficient and what areas need to be developed in order to build a rover. It will also let us know to what spec we are currently capable of building such a rover.

D. Accessibility

The project would be very ambitious. It would require at a minimum a handful (4-5) members each with different areas of expertise. The members would need that knowledge as well as LaTeX, notetaking, and good research practices. This would be to deliver the MVP. A larger team would be able to accomplish more.

VI. Implementation

This project would involve divvying out the different project areas to the different team members or small groups and each week meeting to discuss progress. The team would take this information, refine it and put it into the technical report along with construction.

A. Deliverables

The primary deliverables of this project will be the technical report and the rover itself by the end of the second semester. It is also noted that the materials that the team will come across or notes should also be saved in an Google Drive folder for future reference. The team will also present at SPEX design reviews and the weekly checkups at general meetings with the areas the team members are working on that week. The project is intended to last 2 semesters with the deliverable of a basic rover and a technical report.

The deliverable includes the technical report, Rover software, and Rover hardware.

B. Milestones

The largest milestones for the technical report would be the would be draft and completion. The rover itself would include the various CAD models of the rover, software milestones, electrical system completion, and drive train system.

VII. Externalities

A. Prerequisite Skills

The project is going to require members that are knowledgeable in mechanical design and manufacturing, software engineering, machine learning, electrical engineering, and project management. These members will also need to be experienced in research and design document work. Though this seems simple, finding SPEX members to do this well may be a challenge duye to competition from other projects.

B. Funding Requirements

The rover project is looking at a minimal funding amount of $500.00 USD from RIT SPEX. In order to give a better deliverable the team will also be reaching out to a large list of companies looking for further funding through sponsorship.

C. Faculty Support

Support from faculty could greatly advance this study and what RIT SPEX is capable robotics wise. The team should reach out to professors for advice and help.

D. Long-Term Vision

The long-term vision of this project is to open RIT Space Exploration up to a new area of projects and development. Robotics and rovers are at the core of deep space exploration and most science missions. The project is also intended to lead into a future rover project with expanded capabilities. The University Rover Challenge is hosted by the mars society. It features very competitive and expensive rovers. These rovers feature autonomous navigation, fine control robotics, scientific drill and more. It is a worthy long term goal.

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