Project Report:
NASA/Robotic Mining Competition Rover

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Introduction to Problem

NASA needs to develop more advanced technology for safer and cost-efficient space exploration while ensuring their future in the space exploration industry

NASA's plans the Artemis Mission to the moon by 2025

Artemis Mission part of NASA's next "Giant Leap" - Mars

Extended missions into space are becoming too expensive and we have limited resources on earth

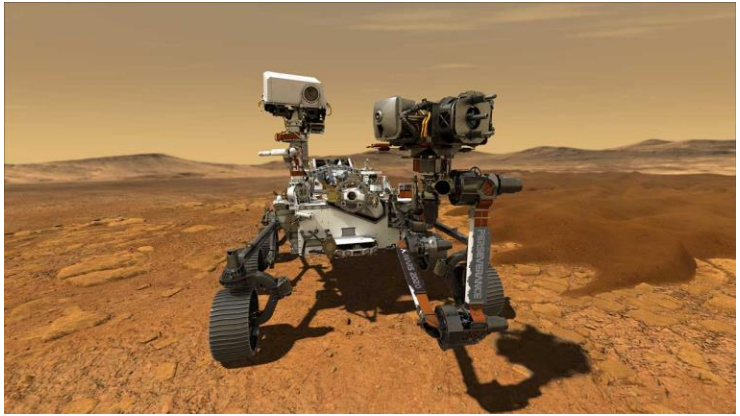


Image Source: nasa.gov [1]

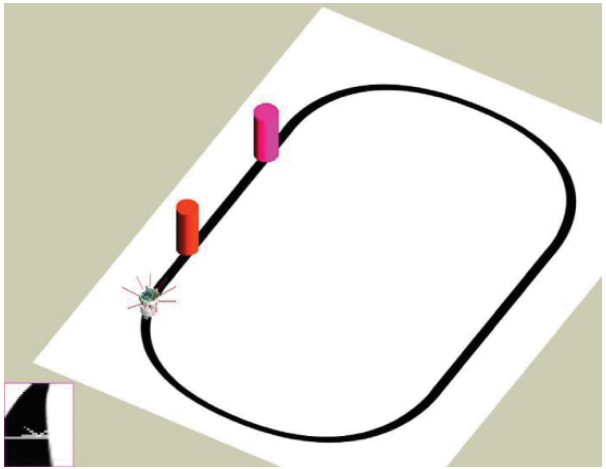
Objective

- NASA's Solution to both problems: The Lunabotics Competition
  - A university level competition where teams that are comprised of at least two undergraduate students and a working robot will compete to demonstrate full operation and capability of the robot and its's ability to maneuver through a simulated environment and mine rock/gravel
  - Each spring, the competition is held at Kennedy Space Center in Meritt Island, FL
- University of Arkansas's Team: The Razorbotz
  - Team of undergrad and graduate students at the U of A devised of many sub-teams: Electrical, Excavation, Chassis, and Computer Science
  - Faculty advisor for our capstone project is Mechanical Engineering Associate Professor, Dr. Wejinya
- Our goal is to design a prototype robot that will master the complexity of maneuvering through rough terrain while mining regolith simulants

Key Concepts and Related work

Autonomous Navigation

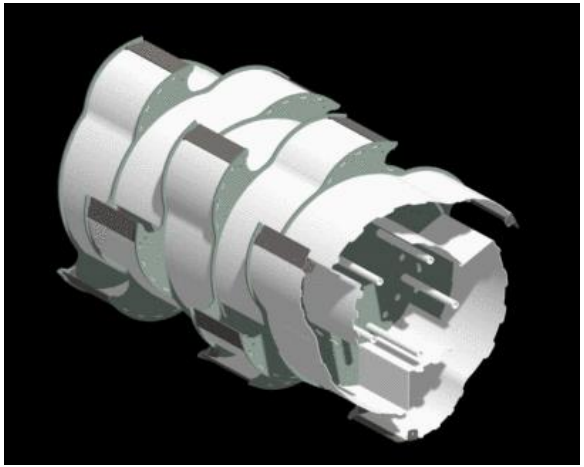
Trajectory Planning and Collision Avoidance Algorithm for Mobile Robotics



Collision detection and avoidance [2]

Excavation

Regolith Advanced Surface Systems Operations Robot (RASSOR)



RASSOR excavating drum without end caps [3]

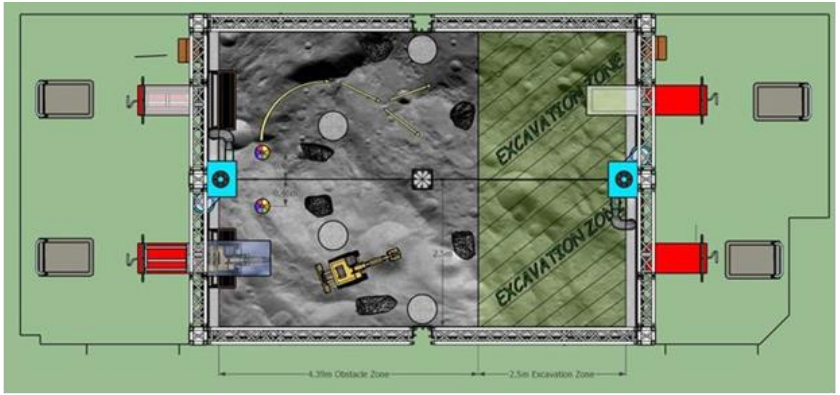
Requirements and Design Goals

Requirements

- Size limitations
- Remote communication
- Kill switch
- Arena navigation

Design Goals

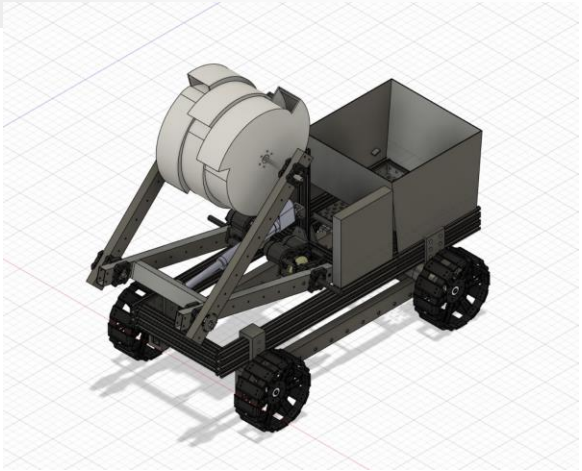
- Complete autonomy
  - Arena navigation
  - Excavation and unloading
  - Shifted towards manual control
- Update and Standardize documentation

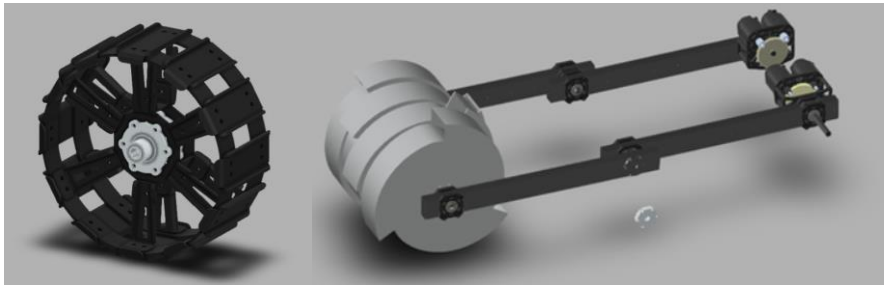


Lunabotics competition arena

High-Level Architecture

- Chassis
  - 39.4” x 12” aluminum t-slotted extrusion frame
  - Custom 3D printed wheels
- Drive
  - 2 REV Brushless motors mounted to rear wheels
    - Subject to change since 04/23/22
  - Belt drive through extrusions enable all wheel drive
- Excavation
  - 2 ODrive motors drive excavation drum via in-extrusion belt drive
  - Extends and retracts via linear actuator
- Microcontroller
  - Powered by NVIDIA Jetson NANO
  - Designed specifically for AI applications

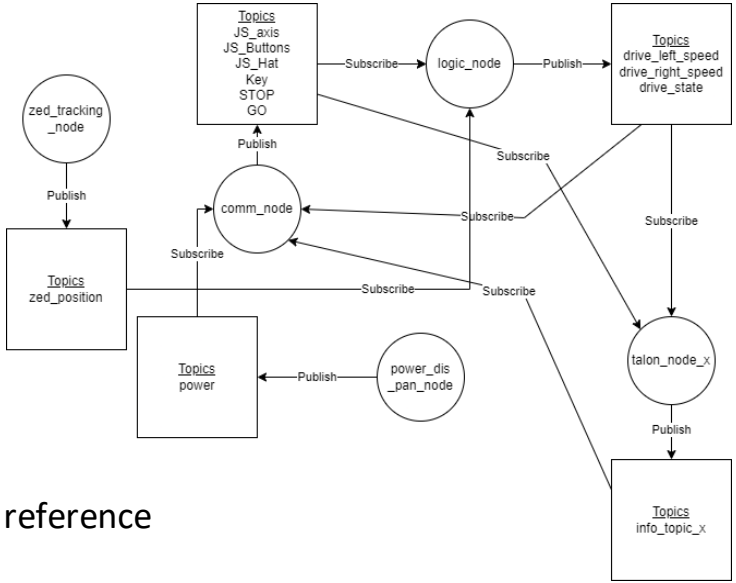




CAD Model of Rover, Wheel, and Excavation tool

ROS Node Architecture

- Communication
  - Takes topics from the Talons, power, and motor speed and publishes its information
- Excavation
  - Utilizes ODrive motors SDK to use the arm and drum of excavation device
- Logic
  - Publishes Zed and Communication info into topics
- Power Distribution Panel
  - Publishes power measurements to other nodes
- Talon
  - Utilizes Talon SDK to set the speeds of the motor
  - May be replaced by NEO motors
- Zed
  - Uses Zed SDK to detect known marker for point of reference



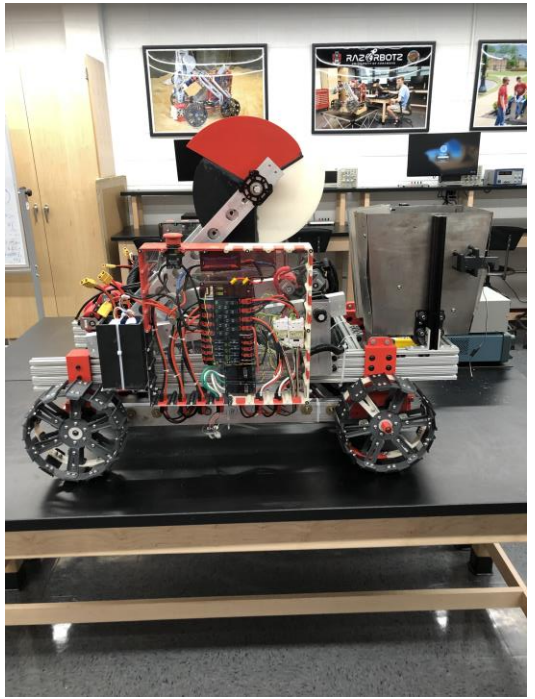
ROS2 Node Layout

Project Results

The team was able to gather a proof of life for the competition. The wheels will spin along with the excavation tool. To the right is a photo of this year's robot model and below is a demo video of all the moving parts.

Robot Demo

2021-2022 Razorbotz's Robot



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Deliverables

- Systems Engineering Report
- Doxygen Code Documentation
- Capstone Project Website
- Razorbotz Code in GitHub Repository
- Final Report

Obstacles and Challenges

Challenge 1: Communication related challenges between sub-teams	Solution: Slack application used for communication and weekly meetings
Challenge 2: Post COVID-19 related obstacles	Solution: Create virtual spaces for meetings and project development
Challenge 3: Difference in design expectations between sub-teams	Solution: Work to establish a more consistent manner of communication
Challenge 4: A large amount of background information needed by every individual	Solution: Ask many questions and conduct personal research outside of team meeting times
Challenge 5: The completion date of the first prototype robot was heavily delayed	Solution: Search for and complete tasks that are available for development while current tasks are unavailable for progress.

Future Work

Full Autonomous Robot

- Further implementation of the Navigation Autonomy.
- Further implement the camera functionality.
- Implement the excavation autonomy to mine rocks on the mining site without human interaction.
- Implement the dump autonomy to recognize the dump site in the arena.

Documentation

- Create better guides that new members can easily read to gain knowledge about the project.
- More thorough documentation of the code that is used for manual and autonomous operations.

References

[1] "Mars 2020 Mission Perseverance Rover", NASA, 2020.
url: https://mars.nasa.gov/mars2020/

[2] M. M. Almasri, A. M. Alajlan and K. M. Elleithy, "Trajectory Planning and Collision Avoidance Algorithm for Mobile Robotics System," in IEEE Sensors Journal, vol. 16, no. 12, pp. 5021-5028, June15, 2016, doi: 10.1109/JSEN.2016.2553126.

[3] R. P. Mueller, R. E. Cox, T. Ebert, J. D. Smith, J. M. Schuler and A. J. Nick, "Regolith Advanced Surface Systems Operations Robot (RASSOR)," 2013 IEEE Aerospace Conference, 2013, pp. 1-12, doi: 10.1109/AERO.2013.6497341.