Muad'Dib

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Red Rocks Community College Space Grant Robotics Team - 2024-2025

Abstract

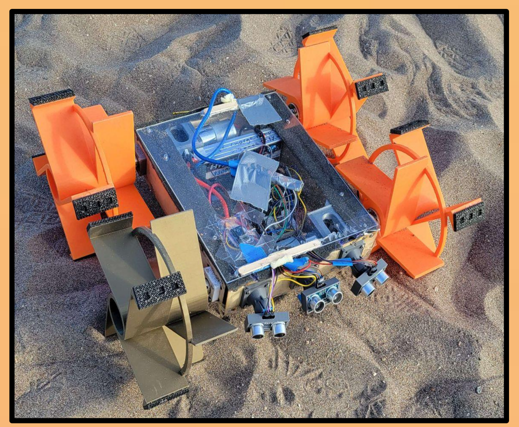
Our goal was to create a sophisticated robot able to navigate completely autonomously on varying terrain, such as soft sand, rough rocks, and snow. Additionally, Muad'Dib must be able to detect, maneuver around, or traverse over difficult obstacles. We've had several prototypes, which we have dubbed Mark I & Mark II, and our final model is a rover with a wood-acrylic chassis body and a belt-system drivetrain pulling two wheels at a time. We tested 2 separate wheel designs; one a wide dreadnought wheel, and one a standard rim design with dog-ball grippers attached. We used an Arduino Mega for our motor drivers and the processing of the various sensors, including 3 ultrasonics and an IMU. With perseverance and strategic design, it was our objective to win Outstanding Performance for Navigation & Obstacle Avoidance.

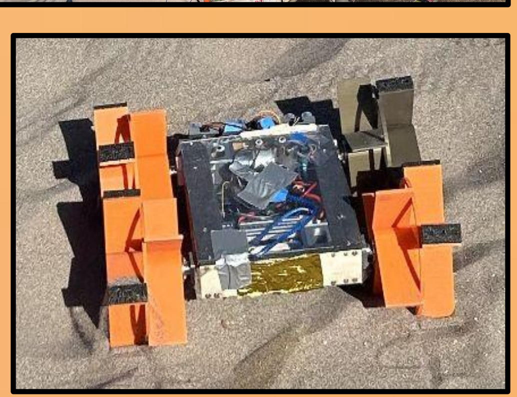
Requirements

- Must be able to identify obstacles and move around them
- Must be able to navigate on varying terrain, such as dirt, rocks, snow, and sand
- <1.5kg, or between 1.5kg and 4kg (ours was **2.7 kg**)
- Must be about the size of a cat
- Total cost must be less than $500 (ours was **$362**)
- No GPS Navigation

Final Design

Our final design features an acrylic and wood chassis with a belt-driven drivetrain, equipped with interchangeable wheel designs. The robot's interior consists of metal, acrylic, and 3D printed materials, designed with modular architecture for control, sensors, and obstacle behavior. It is powered by an **Arduino Mega** and utilizes three ultrasonic sensors and an IMU sensor for orientation logic. To ensure sufficient torque for obstacle avoidance and traversal, we have two low-rpm, brushed gear motors and a **15 V lithium battery** to make sure we have enough power. Our chassis was designed to be modular so each side of the drive can be taken off and worked on separately, specifically working on the tensioning drive train components and belts.





Design Process

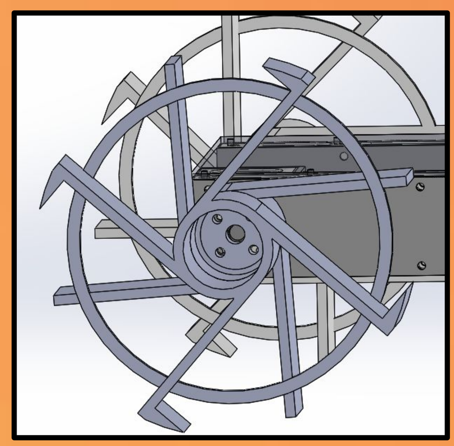
Fall 2024 Semester

- We first voted on the basics of the robot: the use of wheels vs. the use of tracks.
  - We chose wheels due to their lower mechanical complexity, reduced power consumption, and better compatibility with laser-cut chassis materials. (**Reference 1)**
- From there, we split into 3 groups:
  - Drivetrain (**Reference 2**)
    - We decided on using **Greartisan, 12 V, 50 RPM** motors. From there, we used 3D modeling to design a drivetrain around it.
    - The final plan used 2 motors mounted on opposite sides of the chassis, each driving a belt system that powered two wheels per side — giving us simulated 4-wheel drive using just two motors and a passive drivetrain.
  - Chassis (**Reference 3**)
    - We split the chassis into 3 compartments, to keep the inside sand-proof.
      - 2 side compartments held the drivetrain systems.
      - 1 middle compartment held all of the electronics, and the battery.
      - Made of ABS, PLA, laser cut wood, and Acrylic PLA.
  - Electronics
    - Originally, we wanted to use IR sensors as well as ultrasonic sensors. However, IR sensors failed to work due to light interference.
    - We also integrated IMU for serial debug monitoring and directional correction.

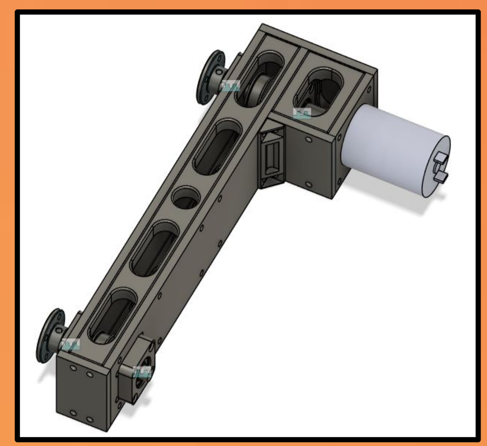
Spring 2025 Semester

- We dissolved the 3 subteams and created 2 new subteams.
  - Mark I Robot
    - This robot started off as a means of creating an additional circuit and navigational code, allowing us to easily switch out and test different sensors to see what worked best.
    - Using this prototype, we decided on **3 ultrasonic sensors** (center, left, right) and **an BNO085 IMU** for orientation and pitch/yaw correction.
    - A block diagram was developed to visualize subsystem interactions between the IMU, sonar, motor control logic, and obstacle avoidance routine. (**Reference 5**)
  - Mark II Robot (**Reference 4**)
    - This robot was intended to be the final chassis and mobility platform.
    - Over the first part of the spring semester, we focused on CAD modeling, frame redesign, and chassis balance testing.
    - The frame was fitted with interchangeable wheels, of which the **dreadnought-style wheels** was our primary. (**Reference 6**)
- A few weeks before the competition, we combined both teams to finish the final rover.
  - All subsystems — motor control, IMU stabilization, flipped state recovery, and ultrasonic navigation — were integrated into a **single control loop**.
  - Field testing began with full autonomous navigation enabled; we performed debug passes on motor torque testing, obstacle avoidance, and flip handling. (**Reference 7**)
  - Unfortunately, the acrylic cracked last minute and we had to switch out the side panels for laser cut wood. (**Reference 8**)

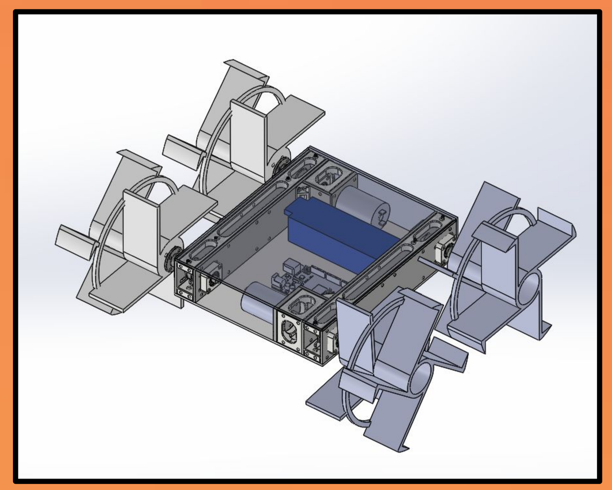
1 - Wheel model



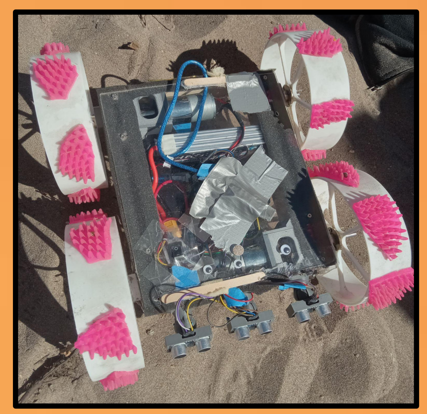
2 - Drivetrain model



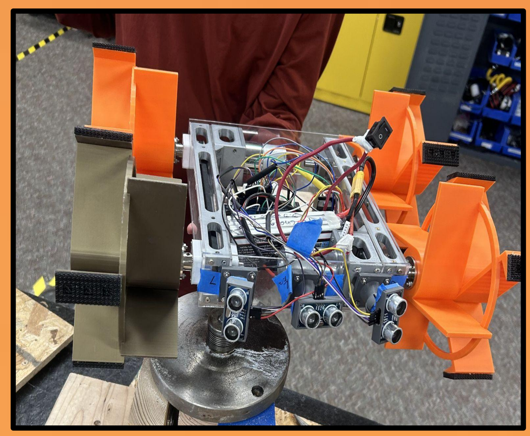
3 - Chassis Model



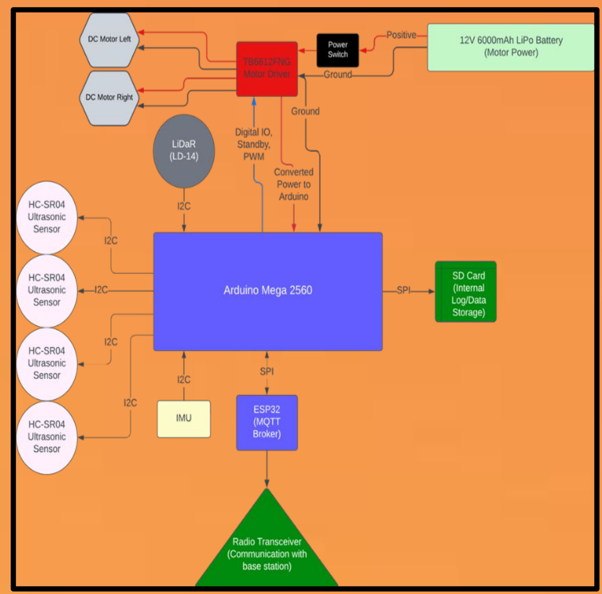
4 - Mark II Robot



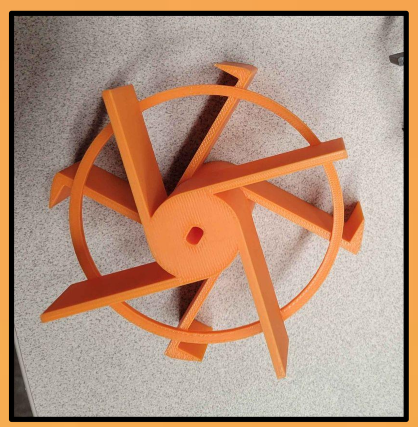
4 - Mark II Robot



5 - Functional Block Diagram

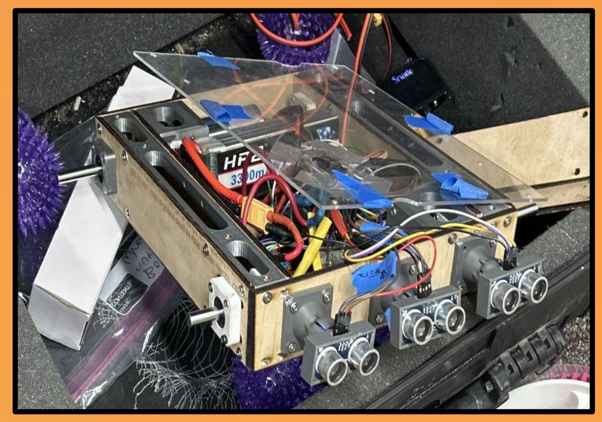


6 - Wheels: Dreadnought Iteration



7 - First Moving Prototype of Muad'Dib (Croc for scale)

8 - Wood Frame



Conclusion

Our journey with Muad'Dib has been one of innovation, collaboration, and problem-solving. Through careful design and rigorous testing, we have developed a rover capable of navigating challenging terrain while demonstrating advanced obstacle avoidance. While the robot had trouble with ditches and going up hill, it performed extremely well avoiding large obstacles & powering over small rocks. Both iterations of wheels performed well, completing **3 of the 5 courses**, with a hybrid version accomplishing the **4th**.

With our excellent navigational coding, innovative drive-train, and extraordinary teamwork we succeeded in winning Outstanding Performance for Navigation & Obstacle Avoidance.