Southeast Conference Hardware Competition

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1 Executive Summary

The IEEE SoutheastCon Mining Mayhem hardware competition has challenged teams to design and build a robot capable of autonomously collecting and sorting materials in a constrained playing field. This report documents the objectives, design considerations, and preliminary plans for implementation. The competition's objective is to create a robot that effectively collects, differentiates, and deposits objects within a structured playing field. This playing field is designed with zones for start gate exiting, material collection, and container placement. The competition assigns points based on task completion, therefore, precise navigation and efficiency in task execution are critical for maximizing our score within the allotted 3-minute time frame. To address the competition's challenges, we decided to design the robot with a modular approach, integrating a scoop for collection, a halt sensor for material differentiation, and a conveyor system for sorting. Central to our robot's operation is a Raspberry Pi for processing, along with supporting components such as servo motors, motor controllers, power distribution, and a robust chassis. As the project is currently in the build phase, the robot has not yet been tested. This report serves as the foundation for the next stages, including assembly, programming, and testing, which will be carried out in the upcoming semester. This document establishes a strong foundation for the continued development and optimization of the robot, with the ultimate goal of achieving competitive performance.

2 Introduction

The IEEE SoutheastCon Hardware Competition is an annual event designed to provide college students with a hands-on learning experience in robotics. Participants work in teams to design, build, test, and program fully autonomous robots that compete in a specified game scenario. The competition is part of the IEEE SoutheastCon conference, which serves Region 3 of IEEE. [1]

Figure 1: Mining Mayhem

In 2047, following the successful deflection of asteroid, 2047-5-L1 by GRID, two valuable materials Geodinium and Nebulite were discovered within the asteroids. Teams are tasked with designing a rover to collect these materials, quickly before the asteroids disappear into space. The objective is to maximize the collection of Astral Materials, and deliver them to specified rendezvous points within; a tight time frame.[1]

3 Objective

The primary goal of the Mining Mayhem competition is to earn points by completing specific tasks with the autonomous robot. The match begins with either a Start LED signal or a start switch, after which the robot operates autonomously using pre-programmed instructions and sensor inputs. Teams can earn points by performing the following actions during three qualification matches that last three minutes each. The highest-scoring one will be used to determine placement in elimination matches:

3.1 Scoring

Points earned during the match

1. The robot leaving the landing site is worth five points.
2. If the robot leaves the landing site within three seconds of the start LED being turned on, an additional five points is awarded.
3. Five points awarded for the robot being in the cave at any time during the match.

Points earned after the match

1. Cosmic Shipping Containers
   (a) Each cosmic shipping container in a non-telemetry selected rendezvous pad earns fifteen points.
   (b) Each cosmic shipping container in a telemetry selected rendezvous pad earns thirty points.
   (c) If a cosmic shipping container is in two or more rendezvous pads it only scores as in the highest value pad.
2. Astral Materials
   (a) Each astral material supported by the robot unit earns one point.
   (b) Each astral material in the wrong cosmic shipping container is worth two points.
   (c) Each Nebulite that is in sorted into the Nebulite cosmic shipping container earns five points.
   (d) Each Geodinium that is sorted into the Geodinium cosmic shipping container earns six points.
3. Team Beacon
   (a) If the team beacon has at least some portion of the object in the top facing hole of the beacon mast it earns forty points.

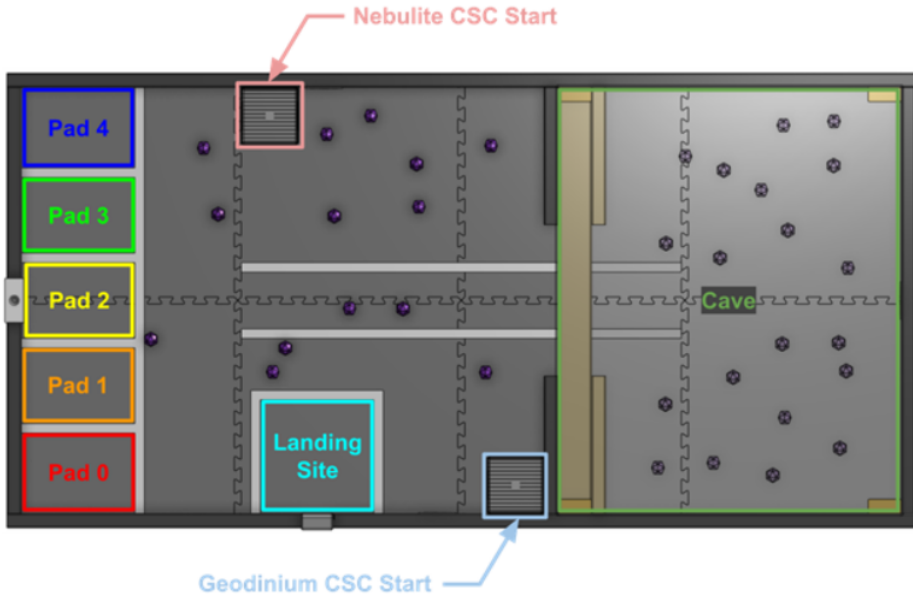

Figure 2: Field

4 Playing Field

The competition field is designed with various zones and elements, including:

3D Printed Elements Various components for the course.

1. Nebulite: Competition astral materials to be collected by the robot.
2. Geodinium: Competition astral materials with magnetic core.
3. Beacon Mast: Holds the team beacon.
4. Start LED Stand: Indicates the match has began.
5. April Tags: Course telemetry.

Landing Site The landing site is a 12 X 12 inch area indicated by tape where the robot will be placed at the start of the match.

Cave A designated zone with unique features where robots can earn additional points. In order for the audiences to see what is happening in the cave, there will be an IR emitting infrared camera inside the cave.

Rendezvous Pads A scoring area on the west side of the field that is designated by tape that consist of five rendezvous pads marked by the a tape ladder. Each rectangle formed by the inside perimeter of the tape and field walls are potential scoring locations for cosmic shipping containers. Each pad has a number starting from southern most area of the course with an id of zero and incrementing up to the northern most pad that will have an id of four. The robot will collect as many astral materials as possible and put them into cosmic shipping containers and bring them to the rendezvous pads.

5 Robot Design

The design process for our robot focused on maximizing efficiency and functionality within the constraints of the competition's three-minute task completion time. The robot needed to perform four primary tasks: exit the starting gate upon detecting a flashed LED, pick up objects, sort them, and place them in specific containers. From the outset, we aimed to create a design that could perform multiple tasks simultaneously to optimize time and increase precision.

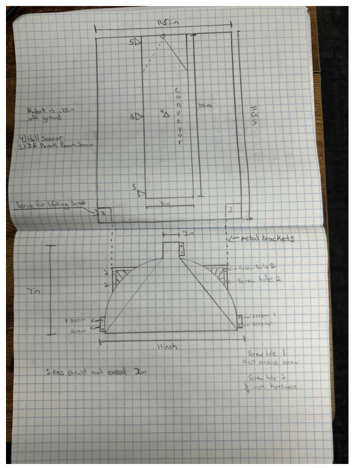

Figure 3: Initial Robot Design

5.1 Key Features and Components

5.1.1 Starting Mechanism

To meet the requirement of exiting the starting gate when an LED is flashed, the robot utilizes a camera paired with OpenCV. This setup enables the robot to detect the LED flash and immediately begin operation.

5.1.2 Object Detection and Collection

- The camera and OpenCV also serve to locate the materials to be collected. This visual processing system provides real-time object recognition, enabling the robot to identify and target specific materials efficiently.
- We integrated a scoop mechanism into the robot for efficient object collection. The scoop was designed to capture multiple objects in a single motion, minimizing retrieval time.

5.1.3 Material Differentiation System

To distinguish between Nebulite and Geodinium, a halt sensor was incorporated into the design. This sensor enables the robot to analyze the material composition, ensuring accurate sorting.

5.1.4 Sorting and Placement System

A conveyor system was employed to transport collected materials to their designated containers. The conveyor's precision-engineered design ensures reliable material delivery and placement, streamlining the sorting process.

5.2 Chassis Selection and Modification

To support the robot's functionality, we purchased a chassis from Amazon. This decision was driven by several factors:

Figure 4: Robot Chassis

Cost-Effectiveness The chassis offered excellent value without compromising on quality.

Durability Constructed from extruded aluminum, the chassis provides a sturdy foundation capable of withstanding the stresses of competition and the weight of the added components.

Mobility Equipped with mecanum wheels, the chassis allows for omnidirectional movement, granting the robot exceptional maneuverability in tight spaces.

Power The DC motors ensure consistent performance and adequate power for all tasks.

To meet the competition's dimensional requirements, the chassis required trimming. Using resources provided by Newton's Attic, we used a DAKE SE 912 bandsaw to carefully reduce the chassis length by 4 inches, ensuring compliance without compromising structural integrity or functionality.

5.3 Control System

At the heart of the robot is a Raspberry Pi, which serves as the central processing unit and the "brain" of the system. The Raspberry Pi is responsible for:

- Processing data from the camera and OpenCV for LED flash recognition and object detection.
- Managing commands for the robot's movement and sorting mechanisms.
- Coordinating communication between sensors and motors to ensure smooth operation.

The Raspberry Pi was chosen for its versatility, computational power, and ability to support custom programming needs, making it an ideal choice for managing the robot's complex tasks.

5.4 Power Distribution

Ensuring consistent and reliable power distribution is critical to the robot's performance. The power distribution system was carefully designed to manage and supply power to all components, including motors, sensors, and the sorting mechanism.

The following components make up the power distribution system:

- Zeee 3S 7200mAh Lipo Battery: Provides a high-capacity power source to sustain all components throughout the competition.
- gobilda Servo Power Distribution Board: Distributes power efficiently to the servo motors, ensuring stable and reliable operation.
- gobilda 6A BEC / Voltage Regulator: Protects sensitive electronic components by regulating voltage and preventing power surges.
- gobilda XT30 Power Distribution Board: Acts as the central hub for power management, distributing power across the robot's systems.
- BOJACK L298N Motor DC Dual H-Bridge Motor Driver Controller Board Module Stepper: Controls the DC motors, enabling precise operation and smooth maneuverability.

This integrated system ensures that the robot operates seamlessly under the demanding conditions of the competition.

6 Conclusion

The IEEE SoutheastCon Hardware Competition not only challenges students to apply their engineering and programming skills in a competitive environment but also fosters teamwork and innovative problem-solving. The Mining Mayhem theme for 2047 emphasizes the importance of speed, precision, and strategy in robotic operations, preparing participants for future technological advancements in robotics.

References

[1] Student Competitions – IEEE SoutheastCon 2025. URL https://ieeesoutheastcon.org/student-competitions/.