IEEE Robotics Competition

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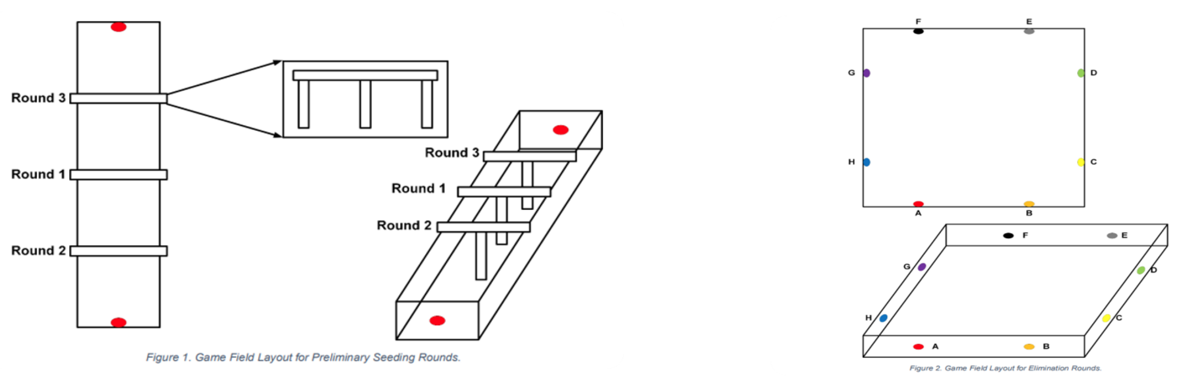
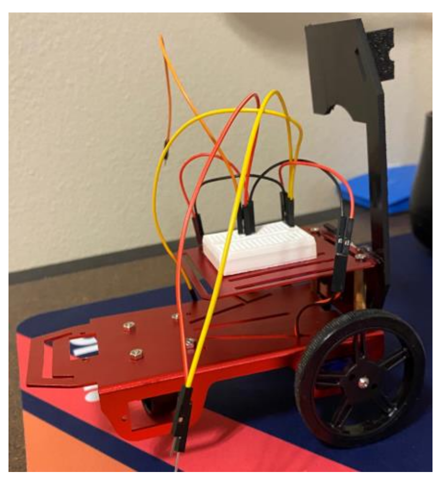
Introduction

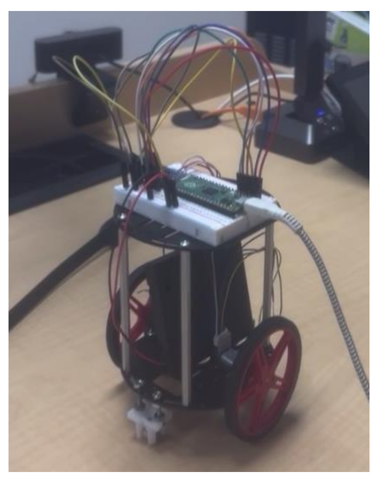
This project explains the details and challenges of a robot designed to compete in the IEEE robotics competition . The IEEE 2024 Robotics Competition challenged teams to design and implement an autonomous robotic system, powered from a capacitor bank, wirelessly charging on a predetermined path of charging stations. Autonomous robots are robotic systems that are designed to operate and perform certain tasks without direct human intervention or control. They can be designed to perceive their environment, make decisions, and execute actions based on inputs to achieve a specific goal autonomously. The competitions difficulty lies in combining many of these challenging issues: autonomy, low energy storage constraints (supercapacitors), while navigating around other autonomous robots. In this year's competition we were presented with two distinct challenges: navigating down a track to press a button and maneuvering around competitors along a predetermined path on supercapacitors to charge at designated stations.



Design Iteration

The team went through a couple of chassis iterations going from a full metal design to a slightly larger 3D printed, ABS plastic, chassis. While larger it is much lighter because of the material and can house the components and the added sensors. In the original design, a single ultrasonic sensor was used. After testing, our results found that sensors don't like reading at angles and the robot would veer into walls, resulting in point deductions. Also, the team experimented with different processors and programming languages before landing on the final Adafruit Feather nRF52840 Express.





Hardware Breakdown

The robot utilizes an Adafruit Feather nRF52840 Express as the brain of the operation. (3) HC – SR04 ultrasonic sensors are used to analyze the surrounding area and this information is processed in the code and an algorithm is executed. Based on the decision made by the microprocessor signals will be sent to the DRV-8833 motor driver board and send power to the motors to travel in whichever direction is desired. Wheel encoders are built into the motors chosen. The encoders are used to verify the robot is driving straight and to have an accurate measurement of where the robot is located within the arena.

Analysis and Evaluation

The majority of our analysis and evaluation was focused on supercapacitors. This is due to the second round of the competition being solely based on running a robot, inductively, through charged supercapacitors. For the inductive charging, the transmitter, which would be connected to the wall, is powered at 9 volts in which the receiver only receives 5V at 500 mA. We chose two different supercapacitors, 30F and 220F, to conduct our testing. The first graph in Figure 2, iis Charging Time for Caps. There was a rule that the supercapacitors only had a 10 second charging time for each charging station. The graph is composed of an Energy in joules on the Y-axis, and Time in seconds on the X-axis. The equation that was used to plot the linear line was a voltage multiplied by a capacitor range from 0 to 220. As seen, this proves to be quite a challenge and we realized that some type of boost to the voltage was needed. Our second graph, RC Time Constant, is for how long it takes our capacitors to discharge from a given voltage with different loads. For our different loads, a low resistance of 8 k and a higher resistance of 300 kΩ were used. On the Y-axis, a voltage range from 0-5V, due to the receiver being at 5V, is plotted with our X-axis being Time in seconds. The equation that was used to plot the curves was an initial voltage wih an exponent of time divided by the 8 kΩ, or 300 kΩ, load, which is multiplied by our capacitor value. Everything in the exponent is then multiplied by negative one. After composing the first two graphs one supercapacitor alone can't do the job so we tried to incorporate some type of bank. However, the realization that weight plays a crucial role as well popped into our minds. The third graph, Required Energy Based on Weight, displays Energy in Watt Hours on the Y-axis and Velocity in meters per second on the X-axis. The line plotted is of our weight for our robot at 235 grams, or .53 pounds. Overall, these graphs helped us come closer to the conclusion how long our supercapacitors will charge and discharge close to the time limit.

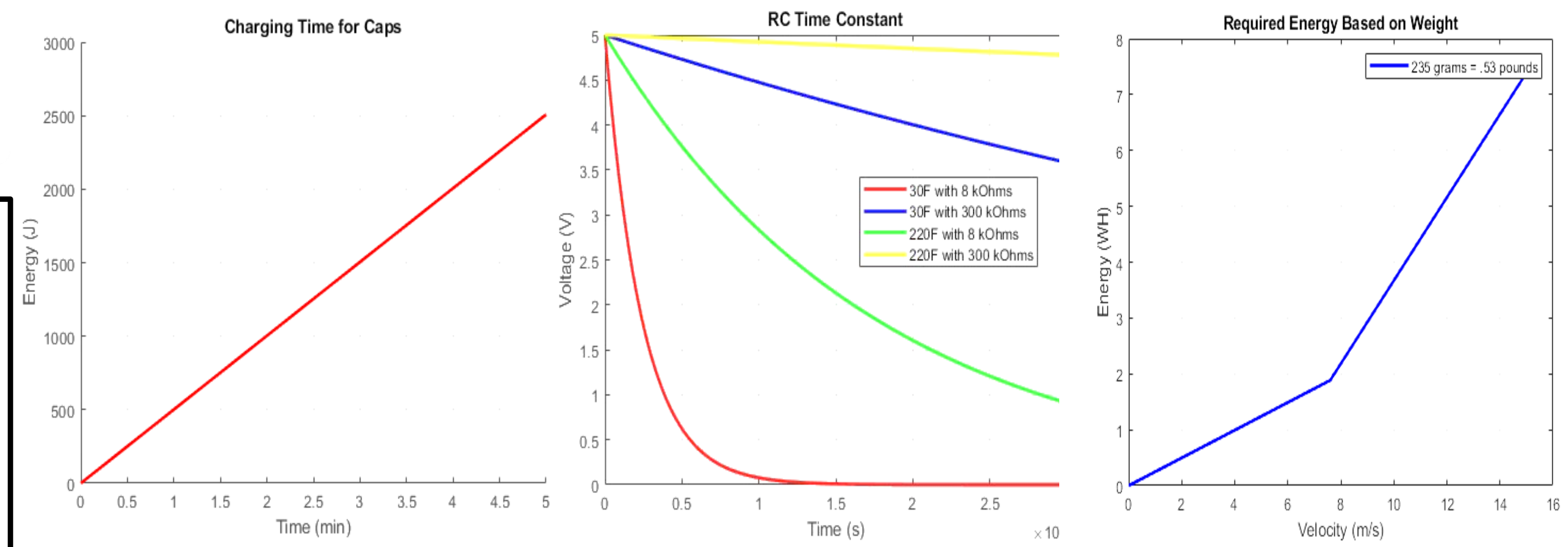


Figure 2

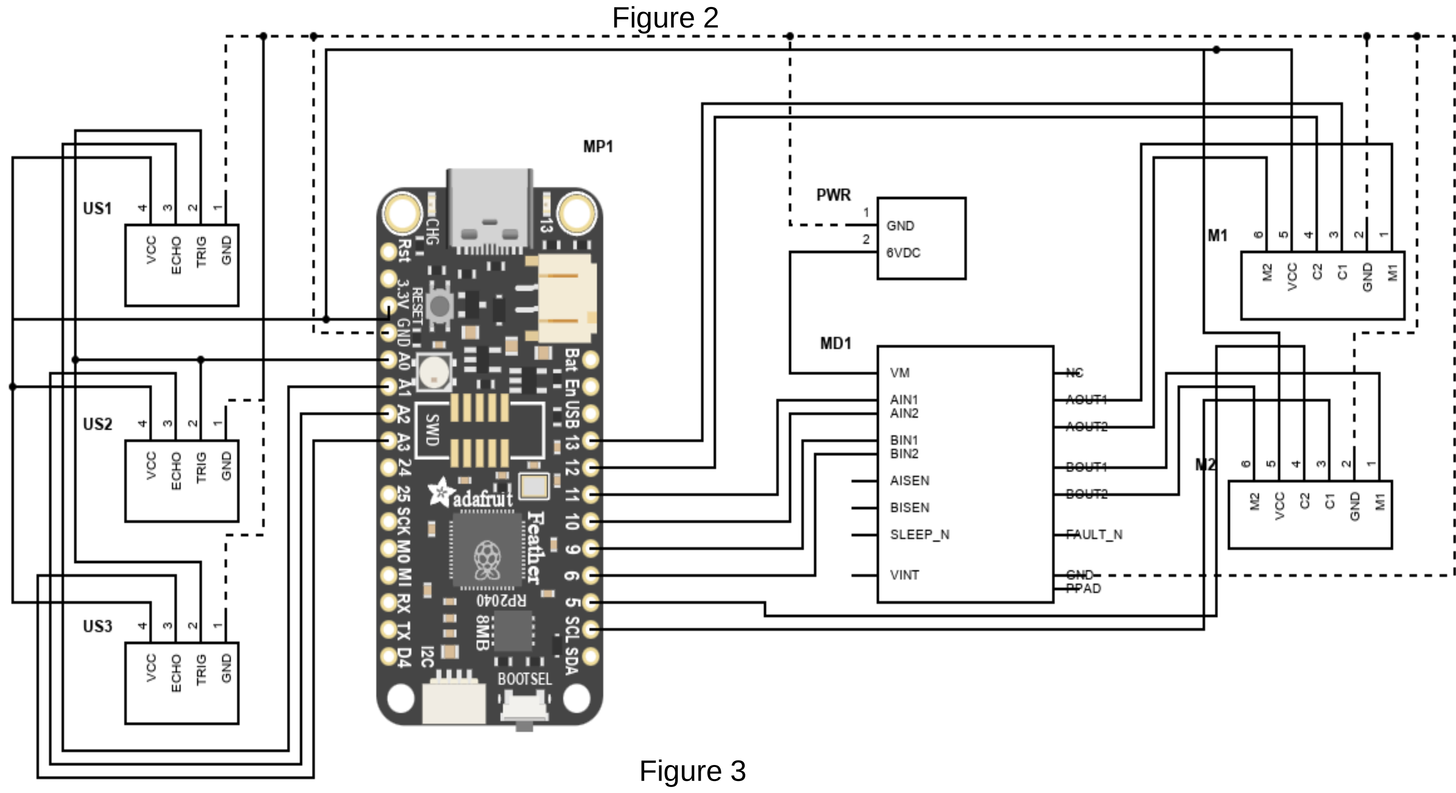


Figure 3

Acknowledgments

ATU IEEE Charter

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Software Breakdown

Given the constraints of using a small, low-power processor running a SLAM(simultaneous localization and mapping) algorithm to map the course wasn't an option. To run a small scale slam program effectively 1-2 gigabytes of RAM is needed. A raspberry PI 4 has these specs but consumes 5W compared to the 33mW of the Feather. Given the RAM capacity of 1.5MB a hard-coded approach with lots of trial and error was required to ensure the robot could navigate the course effectively with the lowest consumption possible.

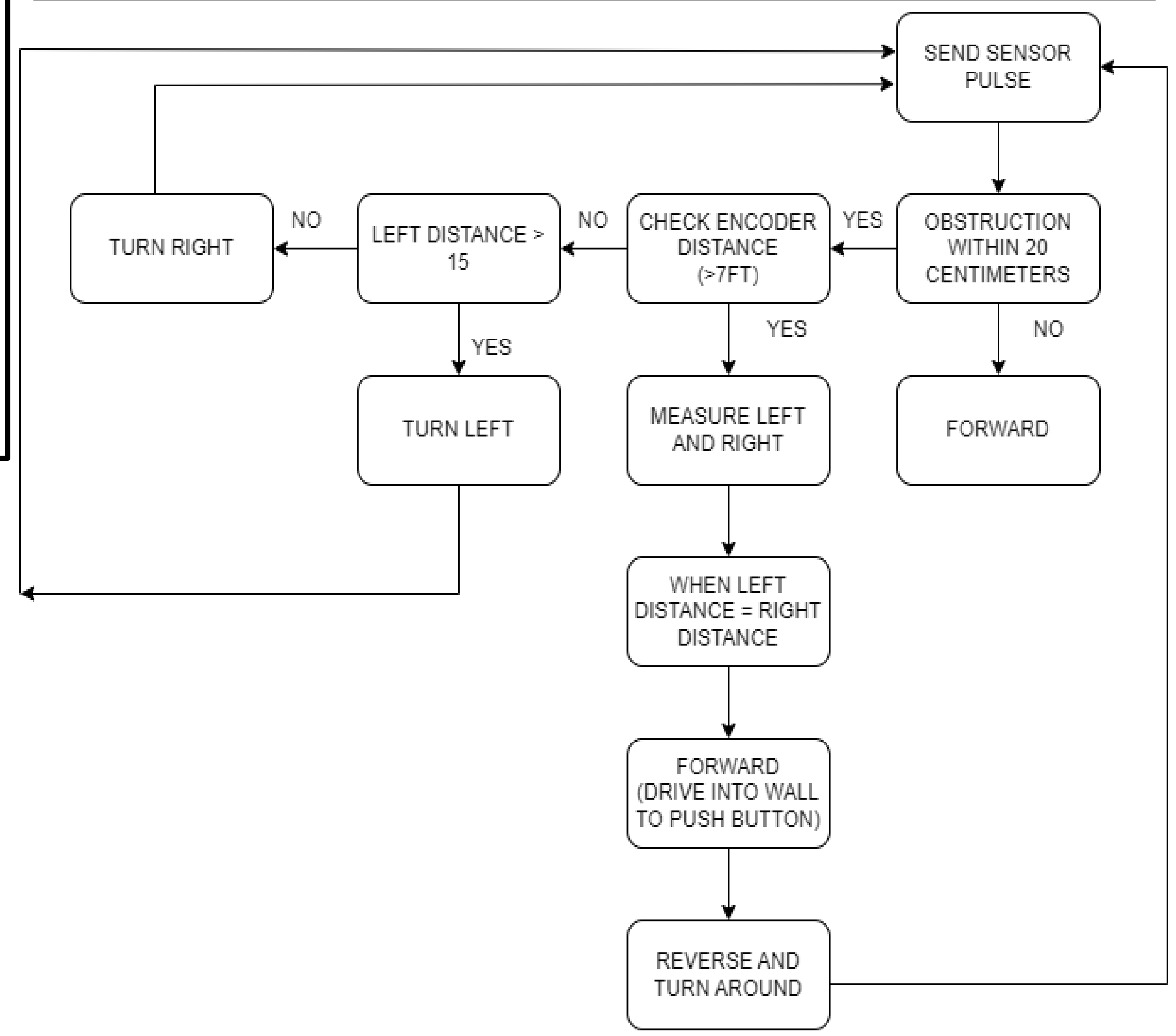

Figure 4

Discussion/Conclusion

The task of creating a robot that would complete the in IEEE Robotics competition was a large one. Making a super capacitor bank that would charge quickly and dissipate slow enough to make it to the next charging station without hitting any other robots was one of the largest obstacles in our research and design. Using the low power ultrasonic sensors (45mW) allowed the robot to go longer but sacrificing resolution and speed. Designing a robot that would avoid all obstacles but would press a button or get close to a wireless charger was too much to ask for these sensors. In the end the team didn't end up competing in the competition but experienced the same successes and challenges a team that competed in the challenge would've faced.

Standards

29 CFR 1910.1200 – addresses the classification of chemicals and materials within workplaces. In the case of supercapacitors, this standard has been employed to assess and categorize them as non-hazardous.

UL810A – developed by Underwriters Laboratories(UL), specifically covers electrochemical capacitors intended for use in electronic products, lighting and power equipment.