Robot Project

Abstract

This report covers our multi-week engineering process with a partner from working with the SparkFun kit to an autonomous robot that can navigate through a maze. During our journey designing the robot, each challenge gave us an opportunity to create a new solution. This project consisted of three different challenges. The first challenge was to build a robot capable of driving exactly four feet straight. The second challenge was making a robot that could navigate through a basic maze with one bend that required a left turn and a right turn. The third robot challenge required us to navigate through more complex maze designs by other classmates and this maze had to be completed by an autonomous robot. These different robot challenges all presented their own difficulties, and even the very first challenge proved challenging at first. But with the knowledge we acquired, it proved possible later.

Our robots consisted of SparkFun kits mounted onto plastic frames that we received and hot-glued together, with two motors controlling linked wheels. These were hooked up to our laptops that ran the Arduino code that controlled the robots. All of the Arduino code that we used was based on and modified from the SparkFun codes 5B and SparkFun codes 5C. We were able to successfully complete each robot challenge.

Design

We initially learned about the breadboard and wiring the SparkFun kits through challenges in class. One standout aspect was our hands-on engagement with wires, connecting them through circuits on the breadboard, and applying the robot practically in the environment. However, something frustrating about this SparkFun kit is that there would be various issues with the robot, and it could be challenging to discern due to multiple factors at play. Ensuring proper code functionality was essential, as well as confirming correct wire connections. Even when the wires were properly connected, they sometimes proved broken and required replacement.

Once we grasped the breadboards, we received plastic base plates, two motors, a hot glue gun, a battery pack, batteries, a zip tie, a ping pong ball, and a mount for the robots. We began by attaching the plastic pieces together and securing them with hot glue. Subsequently, we affixed the breadboard. Moving along the frame near the robots' end, we mounted the battery pack, holding four double-A batteries. On the opposite side, there was a wheel mount for a singular ping pong ball, serving as an all-direction guiding wheel, with wheels connected to motors at the rear. The wheels formed a triangle pattern reminiscent of an airplane, and the two rear wheels moved in opposite directions, requiring code adjustments later where one motor would have a positive value and the other a negative value to move forward.

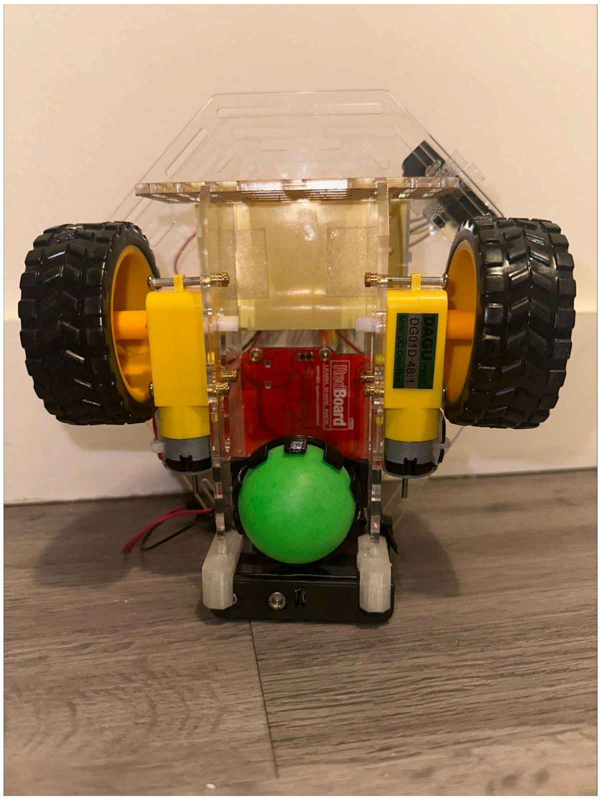

Photo of robot, highlighting the “airplane” wheel system

We intially transformed the robot into the SparkFun 5B in wiring and code. This robot responded to user commands in the serial monitor, determining whether it would go straight, left, or right. However, for the Robot Challenge 1, we needed the robot to operate without being connected to the computer. We altered the code to make the robot move in a specific direction without user input. Figuring this out was relatively straightforward, and my partner and I chose to independently work on solving it simultaneously, leveraging our different perspectives. Collaboratively, we learned from each other's mistakes and pooled our knowledge to solve challenges. The successful setup involved using the same motor and pin modes as the SparkFun 5B code but retaining only the moving forward function, excluding other commands from the serial monitor. Another challenge was achieving a precise stop at four feet. Our approach involved a brute-force method of trying different delays for the function until we found the right number.

For Robot Challenge 2, we utilized the same SparkFun 5B codes and robot build. However, during this challenge, we realized the significant impact of external factors on the engineering process. We discovered that the motors we received exhibited some inconsistency. Despite maintaining a consistent delay with identical code, the robot covered different actual distances each time. This posed a substantial challenge because there was no direct remedy available. Motor replacement was not an option, and even if it were, the issue stemmed from the inherent imprecision of the type of motor we employed; more affordable components tend to be less precise. This scenario mirrors the reality of engineering in which you must adapt to the limitations of the materials at hand.

Using the same robot from the preceding challenge, we reverted to the original 5B code and refined it to include the forward, turn left, and turn right functions. To validate their functionality, we tested the robot on a standard floor, adjusting the delays based on our estimations for maze navigation. Then we conducted trials in which the robot consistently deviated from the intended path, either colliding with a wall, overshooting, or failing to move forward adequately. Although it approached success in some attempts, reaching the last edge, it struggled to complete the maze. Consequently, we continued fine-tuning the code.

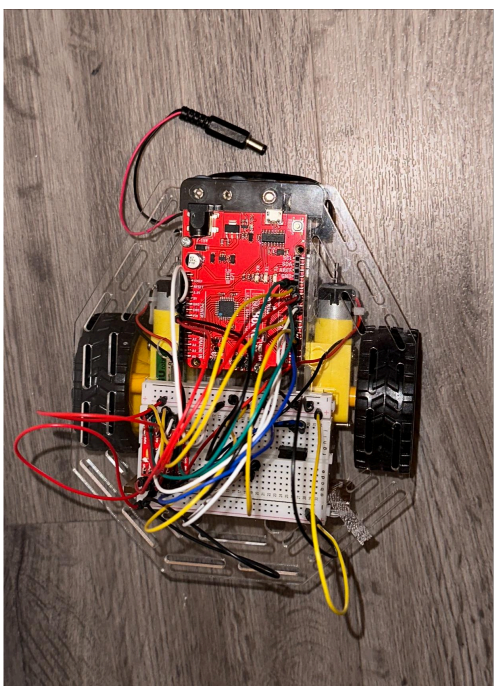

Photo of our modified Sparkfun robot 5B

Eventually, we acknowledged the inconsistent motors were the root cause of the challenges. At one point, we speculated that the motors had been excessively used, potentially leading to their malfunction, resulting in a noticeable decrease in the robot's speed. Seeking guidance from our professors, we took their suggestion of giving our robot a rest. Post-break, we conducted more testing and the robot successfully completed the maze on the 30th attempt.

Following the successful completion of the second challenge, Robot Challenge 3 involved navigating a maze crafted by another group of students. Additionally, we were required to create a maze for another group, designing and constructing it. Leveraging the AutoCAD skills gained in preceding weeks, my partner and I designed a maze.

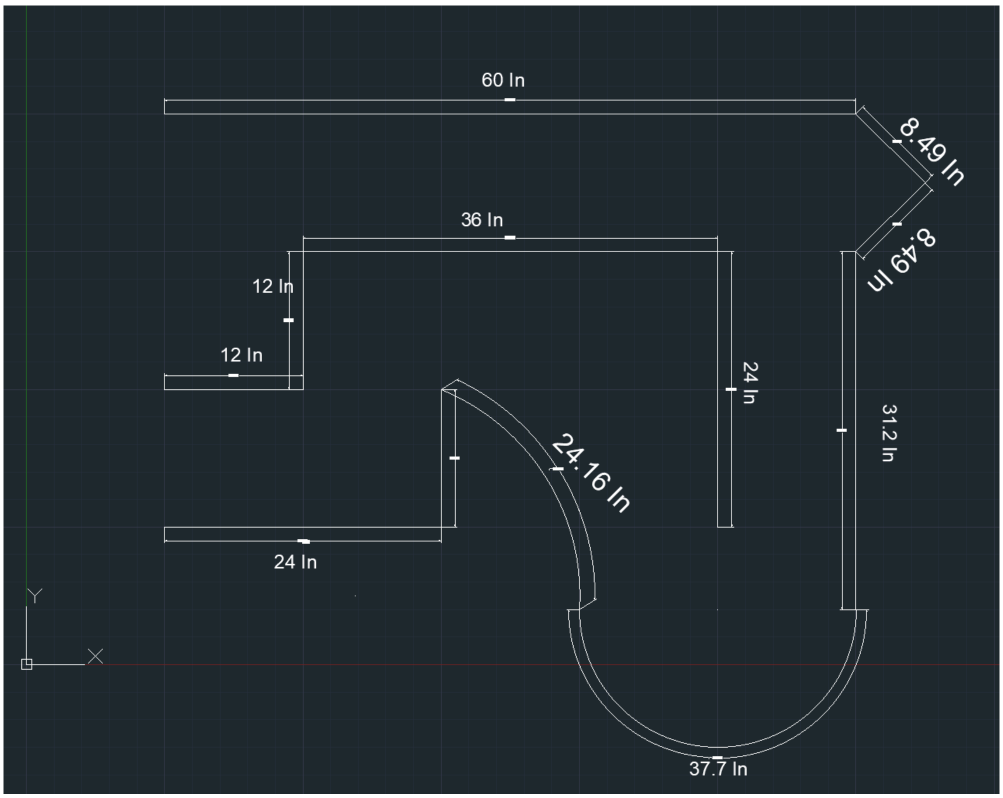

Photo of our maze we designed in autocad

Here, we encountered our next challenge. My partner was unavailable. Up to this point, my partner and I had always been together. But I overcame this by building a large portion of the maze by myself. Afterward, I communicated effectively with my partner about the work I had already done because we needed to collaborate effectively to complete the maze. He made up the work he had to do that I had set aside for him, and the week after, he covered for me.

Photo of the physical construction of the maze we designed

After designing the maze, it was time to proceed to Robot Project 3. This maze featured a lengthy curved edge for the robot to navigate. Surprisingly, I hadn't seen the maze until the final day of navigating it, because it had gone missing. The group tasked with creating it neglected to follow instructions in labeling the maze. However, through a diligent search, we managed to locate it. During my absence, my partner crafted the SparkFun 5C autonomous robot equipped with sensors to detect and follow objects. As previously noted, the equipment lacked precision. Consequently, the ultrasonic distance sensor didn't consistently register distances accurately, posing a challenge for navigating a maze that relied on precise distance information. To address this, instead of relying on a single distance, we utilized ranges of values, providing the sensor with some flexibility to account for potential mistakes. However, the sensor could detect significant jumps in value.

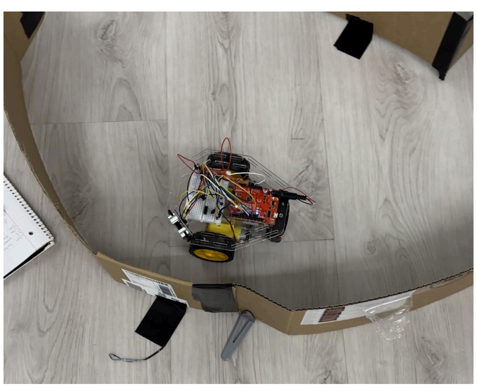

Photo of the maze we had to navigate with our robot inside. The curve is shown.

Conceptualizing the robot's navigation through the maze proved to be quite challenging for us. The introduction of the sensor added an additional layer of complexity to the problem, as the sensor lacked the inherent knowledge of being within a maze. Initially, we positioned the sensor at the very front of our robots, allowing it to perceive the forward space and adjust its course based on distance readings. Although this model showed some success, it was prone to navigating past a wall or two before eventually veering too much to the right or left, leading to backward movement within the maze.

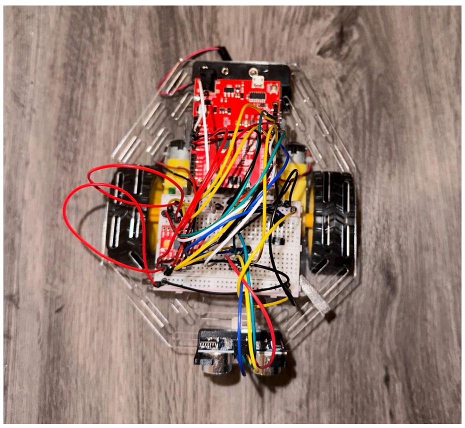

Photo of our robot Sparkfun 5C with the sensor at the front

Using lateral thinking, we drew inspiration from our peers who had their sensors placed on the left front corner at a 45-degree angle, we modified the code accordingly. The revised approach essentially dictated that if an object was within a certain distance, the robot would continue moving straight. If the object was too close, it would turn right, and in the absence of any nearby objects, it would turn left, indicating an open space in the maze. Consequently, whenever a wall was encountered, the robot would recalibrate and resume following the wall.

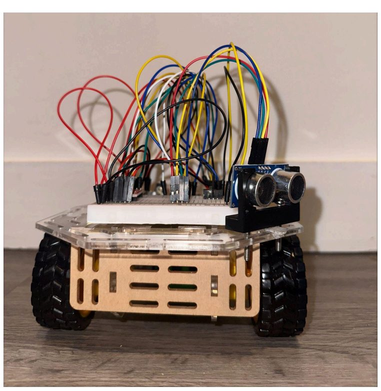

Photo of our modified sparkfun robot with the sensor on the side

While conceptually figuring it out, the coding still took a long time to implement. Additionally we had to concern ourselves with the inconsistency of the motors as reflected earlier. At one point, they failed to even move on the ground, with worse mobility than we dealt with in challenge two. But this time our professors advised us that we needed to replace the power cables on the boards because we short-circuited the wires from the amount of trials. Eventually, after many more trials, the motors were able to complete Robot Challenge 3.

Summary and conclusion

The ultimate iteration of our robots materialized as the SparkFun 5C robots, featuring adjusted codes for following the left wall to the maze's end and an ultrasonic sensor positioned on the front left corner at a 45-degree angle. This project provided a platform to synergize my coding, AutoCAD, circuit, and engineering process knowledge, culminating in the successful navigation of robot mazes, maze design, and robot wiring.

Beyond the acquired skills, this project offered valuable insights. In engineering, the ability to adapt to the situation is crucial, making troubleshooting second nature for us. Interestingly, it was more surprising when we encountered no problems than when we did. The experience underscored the importance of teamwork and communication. Leveraging resources, including professors and fellow students, proved instrumental in accomplishing the task, with their inputs and insights proving invaluable. Notably, for Robot Challenge 3, lateral thinking played a pivotal role in transforming our robots into the functional entities that ultimately conquered the maze.

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