R21: Final Report

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Team B3: The Last RobotB3nder
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Executive Summary

With the Grand Prix approaching, the need for a new pit crew was vital, so the Formula EH competition took place to find the quickest, most efficient autonomous robot to prepare the pits during the race. The Last Robot B3nders were tasked with making the best robot they could in hopes that they would be the pit crew of the approaching Grand Prix.

The team decided to approach the problem through the use of decision and screening matrices. It was decided to use an omnidirectional wheel design, along with a passive rack and pinon arm that also had the capabilities of a forklift. Programming an omnidirectional drivetrain was less straightforward than programming a two-motor drivetrain, so the group decided to use trigonometric functions to control the motor powers. The robot was set as a unit circle, thus allowing the robot to travel at any angle desired with corresponding motor powers. Throughout the testing process, major changes were made including changing the material of the rack and pinion to be made with flexible hairbrush bristles instead of pure MDF, decreasing error.

During the individual competition, the team received a high score of 92/100. Time was the main obstacle as 2 of 3 runs were not finished within two minutes. During the final competition, the team had one perfect run in the first round-robin run, followed by a run of 64 points and a run of 16 points. During the first round of the elimination, the team received a 91/100 and progressed to the sweet sixteen. Thereafter, the team received a score of 80/100 and was eliminated. The robot repeatedly failed to pick up the wrench and press the final button.

The team had successfully created an autonomous robot that was able to effectively complete the designated tasks. In the future, RPS would be switched for bump switches and line following algorithms for increased consistency and decreased completion time.

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1. Introduction

As technology is continuously improved and developed, autonomous vehicles are becoming more prevalent in mainstream media and engineering. Currently, Tesla and Google have popularized autonomous vehicle research, but numerous other businesses are building upon the same idea. In contrast to big commercial vehicles on roads, autonomous vehicles and machinery can also help implement small tasks. For the Formula EH (FEH) Grand Prix, the objective was to make a prototype robot to perform given tasks, acting as a pit crew, in a consistent and timely manner. The team met the requirements to complete the series of tasks with an autonomous robot on the FEH Grand Prix course in the shortest amount of time possible to act as a pit assistant.

1.1 Team Members

The RobotB3nders, or Team B3, consisted of: Amy Huang, builder and documenter, Lauren Pham, who led electrical systems and aided in documentation, Shashank Sawant, lead programmer, and Nabeel Tausif, who worked on design and build of the robot. The course was introduced on January 26th, 2018 and the project started promptly on February 5th, 2018. The final individual evaluation took place on Friday, March 30th, 2018, to demonstrate the performance of each individual robot. On Saturday, April 7th, 2018, a final competition was held to have all 63 competing robots face one another in a test of function, and if need be, time.

1.2 Overview

The rest of the document details the process of making and testing the robot as well as final competition performance. First, the specific requirements of the course are specified. Next, the design process, brainstorming, and initial ideas of how the robot creation and adaptation is detailed. The original ideas that were used in the final design of the robot, utilizing an analysis of different drivetrains and changes resulting from testing is depicted. The robot's final design is specified, including the different features, the budget, schedule, and electrical systems used. The results of the individual and final competition are given, including an analysis of the results. The overall process and design of the robot is summarized, concluding with future improvements and possible revisions to be made.

2. Preliminary Concepts

The robot scenario was introduced on January 26, 2018 with the theme of Formula (EH) Grand Prix. The requirements and restraints of the robot were given. In addition, details about the FEH Proteus Robot Controller were explained and expectations for the entire project were set. Although teams had yet to be formed, students were provided time to brainstorm designs for the body of the robot and specific parts of the robot that would perform each task. The brainstorming process analyzed different individual aspects of the robot, which included a drivetrain analysis, potential chassis setups, wrench delivery mechanisms, and fuel crank mechanisms.

2.1 Requirements & Restraints

The entire course can be found in Figure 1 on the following page; the locations of the different course tasks are also numbered on the figure. The point values for the primary and secondary tasks can be found in Table 1 on the next page. There are 75 available points for primary tasks and 25 available points for secondary tasks.

Table 1: Course tasks and corresponding point values; primary tasks are bolded.

Task	Points
Robot starts within three seconds of start light turning on	9
Touch wrench	8
Control wrench	12
Rotate fuel crank	8
Press a button on the control panel	7
Press button corresponding to diagnostic light	12
Press final button	9
Deposit wrench in garage	8
Rotate fuel crank in correct direction	10
Rotate fuel crank 180 degrees (+/- 20) degrees	7

The robot had to fit within a 9” x 9” x 12” area at the start of each run. The group was given $160 to spend on building the robot. A Robot Positioning System (RPS) provided the coordinates on the ground floor of the course. If the white button on the control panel was pressed for five cumulative seconds, RPS was activated for the upper level of the course. In final individual competition, each team had three attempts to complete the course and receive the best score and time possible, and the best teams progressed forward in competition. Additional information and details can be found in Robot Scenario [1].

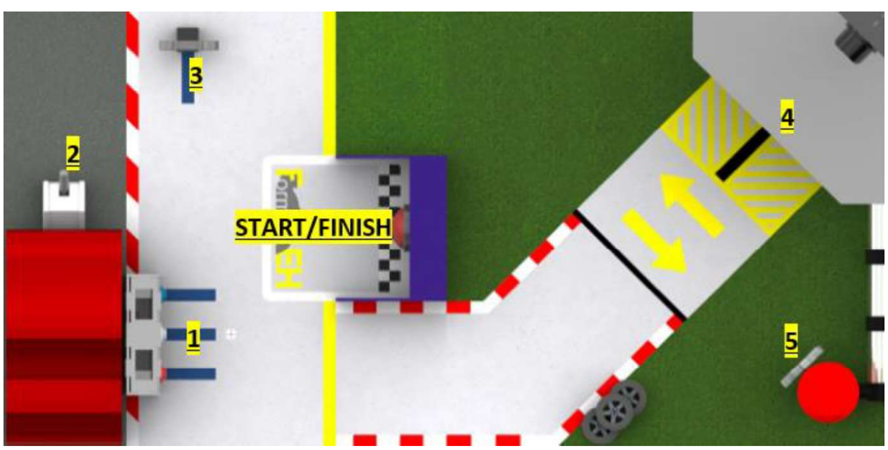

Figure 1: Robot course with task locations numbered.

Table 3: Sample from Master Schedule.

FEH B3 Design Schedule																	
Task Number	Respective Assignment	Name	Description	Scheduled Start	Scheduled Finish	Actual Start	Actual Final	Deadline	Lauren	Amy	Nabeel	Shashank	Estimated Time	Actual Time	Quicker or Slower	Status
1	R05	Mockup: Digital		2/8/2018	2/10/2018	2/10/2018	2/10/2018	2/12/2018	S	C	P	C	120 minutes		quicker	100
		a	Create CAD mockup	2/8/2018	2/8/2018	2/10/2018	2/10/2018		S	C	P	C	120 minutes		quicker	100
2	R05	Mockup: Physical		2/8/2018	2/11/2018	2/10/2018	2/10/2018		C	C	S	P	180 minutes	80 minutes	quicker	100
		b	Collect materials	2/8/2018	2/10/2018	2/10/2018	2/10/2018		S	C	C	P	30 minutes	5 minutes	quicker	100
		c	Create mockup chassis	2/8/2018	2/10/2018	2/10/2018	2/10/2018		S	C	C	P	30 minutes	20 minutes	quicker	100
		d	Create mockup wheels	2/8/2018	2/10/2018	2/10/2018	2/10/2018		P	C	S	C	30 minutes	20 minutes	quicker	100
		e	Create mockup ramp	2/8/2018	2/10/2018	2/10/2018	2/10/2018		C	C	S	P	30 minutes	15 minutes	quicker	100
		f	Create mockup teeth	2/8/2018	2/10/2018	2/10/2018	2/10/2018		C	C	P	S	30 minutes	20 minutes	quicker	100
3	R06	Drivetrain Analysis		2/12/2018	2/14/2018	2/12/2018	2/13/2018	1/0/1900	S	P	C	C	60 minutes	90 minutes	slower	100
		a	Measure course (inches) using the team's decided route	2/12/2018	2/12/2018	2/12/2018	2/12/2018		C	P	S	C	30 minutes	5 minutes	quicker	100
		b	Estimate travel time (not including time to accomplish tasks)	2/12/2018	2/12/2018	2/12/2018	2/12/2018		P	S	C	C	30 minutes	15 minutes	quicker	100
		c	Calculate minumum linear speed to accomplish course within two minutes.	2/12/2018	2/12/2018	2/12/2018	2/12/2018		C	S	C	P	30 minutes		quicker	100
		d	Convert speed into rotations per minute	2/12/2018	2/12/2018	2/12/2018	2/12/2018		P	S	C	C	30 minutes	15 minutes	quicker	100
		e	Estimate mass of robot and convert to ounces	2/13/2018	2/13/2018	2/12/2018	2/12/2018		C	P	S	C	<30 minutes	30 minutes	quicker	100
		f	Determine torque needed by multiplying force by wheel radius.	2/13/2018	2/13/2018	2/12/2018	2/13/2018		C	S	P	C	2 minutes	2 minutes	quicker	100
		g	Divide torque by number of motors to determine torque per motor.	2/13/2018	2/13/2018	2/12/2018	2/13/2018		S	P	C	C	2 minutes	2 minutes	quicker	100

4.5 Electrical Systems

The electrical system was connected to the Proteus using ports. There are three places for ports: motor ports, servo ports, and general input/output ports. Four motor ports were used, one for each Vex Motor 393s used for the omni-wheel drivetrain. They were appropriately labeled Front Motor, Left Motor, Back Motor, and Right Motor and the actual red and black wires were labeled 0 to 3, respectively, to note which motor was associated with each port. The motors were attached with port terminal blocks acquired from the store. The overall block diagram including the exact port locations is found on the next page in Figure 16.

One servo port was used for the servo arm which lifts wrench. One general port was used for the CdS cell, which was used to detect colored lights and distinguished by its red, orange, and yellow wire. The CdS and servo ports were soldered together using provided diagrams provided in the Proteus and Electrical Systems Resources [2], and header strips.

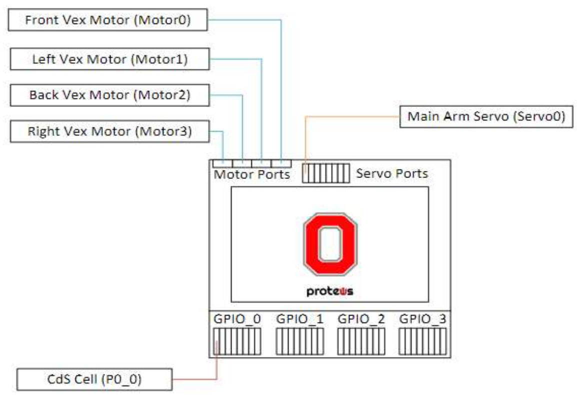

Figure 16: Electrical Block Diagram.

5. Individual Competition

The individual competition took place in room 208 in Hitchcock on March 30th, 2018. Each team had three runs to get the highest score possible in two minutes. The direction for the fuel crank and color for the diagnostic button were chosen randomly for the first run, chosen by the instructor for the second run, and chosen by the group for the third run. The group was given one minute to set up their robot before the official clock started.

5.1 Strategy

The team carefully decided what the best route to take would be. Being that RPS was used a great deal in the checking the location of the robot, it was decided that turning it on by button, causing the team to be ineligible to progress. Having reached their goal of making it to the sweet sixteen, the team was overall content with the robot's performance.

8. Conclusion

The team successfully built an autonomous robot that completed the designated course - navigating through the primary and secondary tasks in a timely manner. The goal for the team was consistency, which was achieved through minimizing the possible flaws that both the robot and external factors caused. This included the robot's ability to run on each robot course independently. Beginning with having the best average score in the class, the team focused on getting the robot to finish multiple runs in a row in the amount of time given without major errors occurring.

8.1 Improvements

After the individual competition, the biggest issue was that the robot was in a race against time. More than half the time, the two minutes would pass and the robot would not be finished with the course. This was speculated to be due to the several RPS checks, which were inconsistent in terms of how long each took. Some runs proved that the robot was capable of completing the entire course in under one minute and thirty seconds, while other runs presented that it was unable to finish the course within the time limit.

The best ways the team saw to reduce time from each run was to increase the overall speed of the robot by using the motors at a higher power, to increase the tolerance during certain RPS checks where total precision was no7t necessary, and to minimize time spent at certain locations such as at the button panel and wrench. Although it seems that some of the proposed methods would only cut down on time by a second or even half a second, it was believed that