FAMU-FSU College of Engineering

IEEE Southeast Con Hardware Challenge 2017
Midterm Report

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EEL 4911C – ECE Senior Design

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Abstract

The students of this project have been tasked with designing and constructing a fully mobile autonomous robot capable of meeting the specifications and needs spelled out by the IEEE Southeast Con Hardware Challenge 2017 rules (IEEE Southeast Division). After evaluating each stage of the competition and researching various solutions to accomplish the tasks, a general idea of requirements has been formed. These requirements will be further examined and specific designs will be formulated from the results of the research conducted. The specific needs and requirements have allowed the students to begin planning the robot design and comprising a general budget to be approved by the project advisor.

Introduction

This group is tasked with the design and construction of a fully autonomous robot capable of meeting the needs and requirements of the 2017 IEEE Southeast Con Hardware Challenge. Each stage of the competition will require various tasks of the robot to be completed as described below.

Stage One will have the robot "uncovering the unknown" (IEEE Southeast Division, 2016), by testing 5 various circuits in unknown configuration to determine what the hidden component is. Each component, a resistor, a wire, a diode, a capacitor, and an inductor, will be assigned a numeric value between and one and five. The robot will then store this information into memory for later use, as well as display the gathered code on a digital display.

Stage Two will require the robot to compete in a "lightsaber duel" (IEEE Southeast Division, 2016). After detecting the presence of a time variant electromagnetic field, "The Force", the robot will initiate repeated contact with the arena's "Lightsaber," only when the field is being momentarily produced.

Stage Three will call upon the values gathered in stage one to "Bring down the shields" (IEEE Southeast Division, 2016). The robot will turn a dial a full rotation for each value collected from the 5 point circuit in stage one. With each value turning the opposite direction of the previous value. With an allowable ±15°.

Stage Four will task the robot to "Fire the proton torpedo" (IEEE Southeast Division, 2016). The robot will be loaded with 3 Nerf N-Strike © Darts and tasked with launching them from a distance determined by the build team varying from 0' to 8' depending on the capabilities and design agreed upon. The target will be positioned 7.5" from the base of the arena and will consist of a 6"x6" square.

Given the tasks above, the robot will need to be designed to encounter each of the stages in an efficient manner. Each stage will be broken down into the specific needs and requirements to be met by the design. Each requirement will have several solutions associated with it and will be evaluated for various factors including cost, implementation, and feasibility.

Project Definition

Background research

As of right now, due to the fact that we do not have all of the required information about the specs we need, it is hard to determine which microcontroller would be most useful one we are looking at include Raspberry Pi, Arduino, and MSP Launchpad.

	Type	Cost	Advantages
Microcontrollers	Raspberry Pi	$40	TBA
	Arduino	$25	TBA
	MSP Launchpad	$20	TBA

Table 1: Microcontroller Options

The robot will have to navigate autonomously around the arena. Potentially, the robot may climb steps to reach have an easier firing of the darts in stage four. The two main drive trains considered are wheeled and tracked robots. Legs are also a possibility. Wheels are very versatile as they come in different sizes and can have a varying number of wheels. Another option, tracks are particularly useful as they move easier through bumpy surfaces and could climb the steps better that the wheels for stage four. Finally, legs could be implemented as they are highly mobile (Benson, 2010).

Type of Motor	Advantages	Disadvantages
Wheeled	Simple design; many options	Slip due to little contact with ground
Tracked	Little skip; distributed weight, able to move on elevated grounds	Difficult to turn; complex mechanically
Legs	Close to natural motion; able to overcome rough terrain or obstacles	Complex coding and design, high power demands, high cost

Table 2: Drive Train Options

Arena Navigation is highlighted in Table A with costs and advantages of each method listed within the table. Ultrasonic seems to be the most promising route, but some more research and time will be needed to determine the components being used.

	Type	Cost	Description
Arena Navigation	Infrared Distance Sensor	$12	The advantages of using infrared sensors are their low-cost, accuracy, and reliability.
	Ultrasonic Distance Sensor	$5	The advantages of using ultrasonic sensors are their low-cost, long range, but paint finishes can affect range accuracy.
	Laser Distance Sensor	$150	The advantages of using laser sensors are their accuracy, much more than the IR and ultrasonic, but the cost is much greater than the IR and ultrasonic sensors.

Table 3: Navigational Options

Stage 1 requires the use of circuit analysis to decipher which component is being used. The components can be seen in the figure below. Things that are needed for this stage is a microprocessor for controlling input voltages to the circuit, as well as a multi-meter in order to read the output voltage/ current. A digital to analog converter may be useful for determining the components for the capacitor and inductor. The correct code will be displayed using some sort of screen. (Table 2)

Code	Component type	Component value
1	Wire	N/A
2	Resistor	10K, 10% tolerance
3	Capacitor	0.1uF, non polarized
4	Inductor	500mH
5	Diode	IN4001–cathode/anode can be oriented in either direction

Figure 1 - Components being used in competition

	Type	Cost	Description
Display	LCD	$6	The LCD has a cleaner look to the design as well as more freedom with characters.
	LED (7-segment)	$5	The LED board is easier to program and requires less pins

Table 4: Display Options

Stage 2 requires the robot to detect a an electromagnetic field produced by a coil constructed from 40 turns of #20 stranded copper wire wound around a 0.5" diameter bobbin. A current of 1 A will be fed through the magnet to generate a positive field (as measured from the front side of the wall on the robot arena side) (IEEE Southeast Division, 2016). The lightsaber will be constructed to contain 8 LED indication lights and a vibration sensor to accurately detent contact, made from the robot to the arena mounted components. These components are as listed in the Table 1.

Vibration Sensor	Tech Specs • Maximum Operating Temperature: 260°C ± 10°C • Contact Time: 2 - 2.5ms Dimensions: • Diameter: 5mm / 0.2" • Height (w/ pins): 23mm / 0.9" • Height (w/o pins): 11mm / 0.4" • Weight: 0.2g
LED Indication Lights	Dimensions: 51.10mm/2"x10.22mm/0.4"x3.19mm/0.12" Weight: 2.57g

Table 5: Lightsaber Technical Components

To meet the needs of the electromagnetic fields, the robot will be equipped with an electromagnetic field sensor. Preliminary research resulted in the Table 2, consisting of a couple options for sensors capable of meeting the needs set. While both sensors operate in the same manor and would produce the required results for this stage of the challenge when connected to the circuit built with the microcontroller, each has a different operating voltage range. This range can change the way in which the sensor is able to operate with the robot and its other components. Design requirements will decide which type of electromagnetic sensor will be needed to successfully take on this stage. The rotational movement needed for the robot's lightsaber to make contact with the arena's lightsaber will be supplied by some sort of rotational motor, see Table 7 for various motor options.

	Name	Cost	Description
EMF Sensors	Honeywell SS495A	$1.41	• Operates between 4.5V to 10.5V • Ideal for various fields, operation proportional to produced field
	Honeywell 2SS52M	$3.23	• Operates between 3.8V to 30 • Can be implemented to operate within more than 1" of the field • Ideal for low fields

Table 6: EMF Sensors

Stage 3 requires using the code from stage 1 to unlock a combination lock. The lock is a quadrate encoder with a RGB LED (Figure 1) and a clear plastic knob attached to it (IEEE Southeast Division, 2016). When the encoder is turned, it outputs a 2-bit gray code that represents the direction and amount of knob turns (Rotary Encoder).

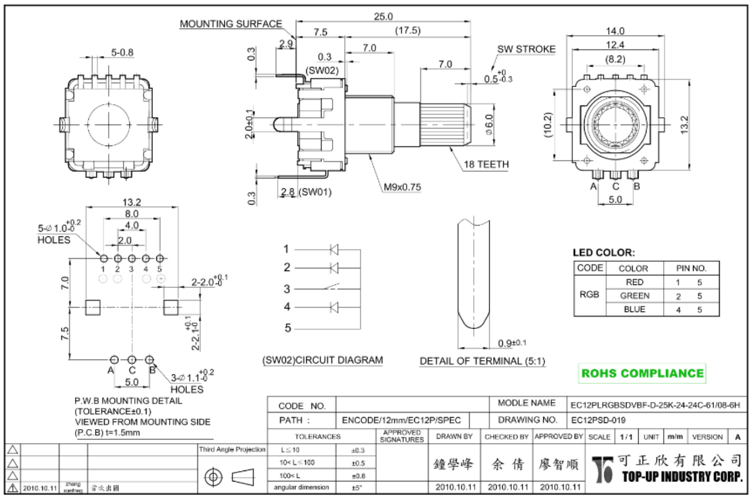


Figure 3: COM-10982 ROHS Data Sheet

Actuators are special types of output transducers. To turn the knob, rotational actuators could be used to transform electrical energy into rotational motion. Two possible types that would efficiently turn the knob are a servo or steeper motor. Servos consist of a direct current motors, a gearing set, potentiometer, and control circuit all contained in one unit. DC motors are rotated by the current. Two terminals determine the direction the motor will spin. Switching the polarity of the terminals reverses the direction of the motor. The speed of the motor is controlled by the current supplied. Servos are precise and have speed control. Three wires control the servo. The first is power, the second is ground, and the third is a digital control line. The digital control line regulates the position of the servo. A coded signal determines the direction and rotation speed. As long as the same signal is applied, the direction and speed of the servo is maintained (Hughes, 2016). Stepper motors are synchronous electric motors that use digital pulses to rotate. The rotation and its direction is divided into steps controlled by a pulse (Stepper Motors).

Type of Motor	Cost	Description
Continuous Rotation Servo	\$5-\$30	Rotates 360°; Fast rotation; Smooth motion
Stepper Motor	\$15-\$30	Easy to control; Simple implementation; Little power; Limited movement
Rotational Actuator	\$5-\$15	Ideal for “flipper” actions; low power draw; Very limited movement

Table 7: Motor Options

Stage 4 requires the robot to fire Proton Torpedoes (Nerf© darts) through a 6” x 6” cutout framed in 1” x 2” wood with the frame located 3.5” (Figure 2) above the top step of the arena. Depending on where the torpedo is fired from in the arena the firing angle may need to be in a positive or negative direction to allow the torpedoes to go through the framed opening.

	Type	Cost	Description
Projectile Firing	Nerf Gun	$30	Precision built for the projectiles being used in competition, however the size of the guns can hinder the robots complete design.
	Hand Built	$30	Would be more suited to the robot's specifications for the size constraints of the competition.

Table 8: Projectile Options

From research the methods to fire a nerf dart are limited to using a stock nerf gun or building a custom nerf firing device that fits the robot. Each method will cost about the same to implement on the robot, and will need further discussion to determine the method that will be used for competition.

Figure 3: Arena Design

Needs Statement

The needs of this project are to design and construct a robot capable of the following. The robot must be small and low cost, capable autonomous operation to navigate and move around the arena, as well as test a five point circuit, detect using sensors for an electromagnetic field, rotate a combinational dial, and fire projectiles.

Objectives and Goals

The overall objectives and goals are to comprise a design that can meet the needs and requirements set by each stage in the Introduction to be successful at the Competition.

Constraints

The constraints on the robot include its cost and size. The estimated budget for this project is $750. Thus, the complete construction of the robot must be at or under this budge. The robot must fit entirely in a 12" by 12" by 12" cube at the start of the match. However, after the run has started, the robot can expand in size or break into multiple independent robots as long as the robot does not exceed the playing surface (IEEE Southeast Division, 2016).

Deliverables
WBS

IEEE Southeast Con Hardware Challenge 2017

- Activities
  - Description
  - Deliverables
  - Duration
  - People
  - Resources
  - Predecessors
- Navigation
  - The robot needs the ability to sense where in the arena it is to engage and complete the stages.
  - Final decision on sensors to be approved by the group and purchased on November 7th.
  - Completed by November 7th
  - Colin
  - Resources
  - Drivetrain, chassis design, microcontroller
- Chassis Design
  - Robot Body designed to house all components and fit within a 10"x10"x10" volume
  - Official designs approved by group and sent to proper machine shop for construction resulting in a complete robot chassis ready for motors, sensors and other various components to be added
  - Completed by Dec 2nd
  - Hunter
  - Resources
  - Drive Train, and Stage 1-4 components must be completed prior to official design implementation
- Microcontroller
  - Microcontroller must be chosen that can house enough pins in order for all parts, servos, and sensors.
  - Official choice approved by group. Part ordered and implemented.
  - Completed by Nov 7
  - Michael
  - Ordered Parts
  - No predecessors
- Power Supply
  - Battery must be chosen that can supply enough power to our robot.
  - Official choice approved by group. Part ordered and implemented.
  - Completed by Jan 9
  - Michael
  - Ordered Part
  - Calculations of power consumption must be completed prior to power supply selection.

- Drive Train
  - The movement system for the robot. Includes the platform and motor controller.
  - Official design approved by group. Parts ordered, constructed, code written, and tested.
  - Completed by Jan 30
  - Nicole
  - Ordered parts.
  - Stage 4 design must be completed prior to official design implementation.
- Stage 1 - "Uncover the Unknown"
  - Circuit component identification process
  - Official Designed approved by group, Parts ordered and ready for implementation, Code Written and ready to be implemented
  - Completed by Jan 30th
  - Ordered Parts
  - Michael
  - Microcontroller must be chosen.
- Stage 2 - "Lightsaber Battle"
  - Electromagnetic Field Sensing and Lightsaber movement
  - Official Designed approved by group, Parts ordered and ready for implementation, Code Written and ready to be loaded
  - Completed by Nov 10th
  - Ordered Parts
  - Hunter
  - EMF Sensor must be implemented before lightsaber motion can be implemented
- Stage 3 - "Bring down the Shields"
  - Implements code into an encoder.
  - Official design approved by group. Parts ordered, constructed, code implemented and tested.
  - Completed by January 30th.
  - Ordered parts
  - Nicole
  - Stage 1 design must be completed prior to writing code.
- Stage 4 - "Fire the Proton Torpedo’s"
  - Fires three NERF darts through a 6”x6” target area.
  - Official design approved by group. Parts ordered, constructed, and ready for implementation, code written and implemented.
  - Completed by January 30th
  - Colin
  - Drivetrain, chassis, microcontroller

Critical Tasks

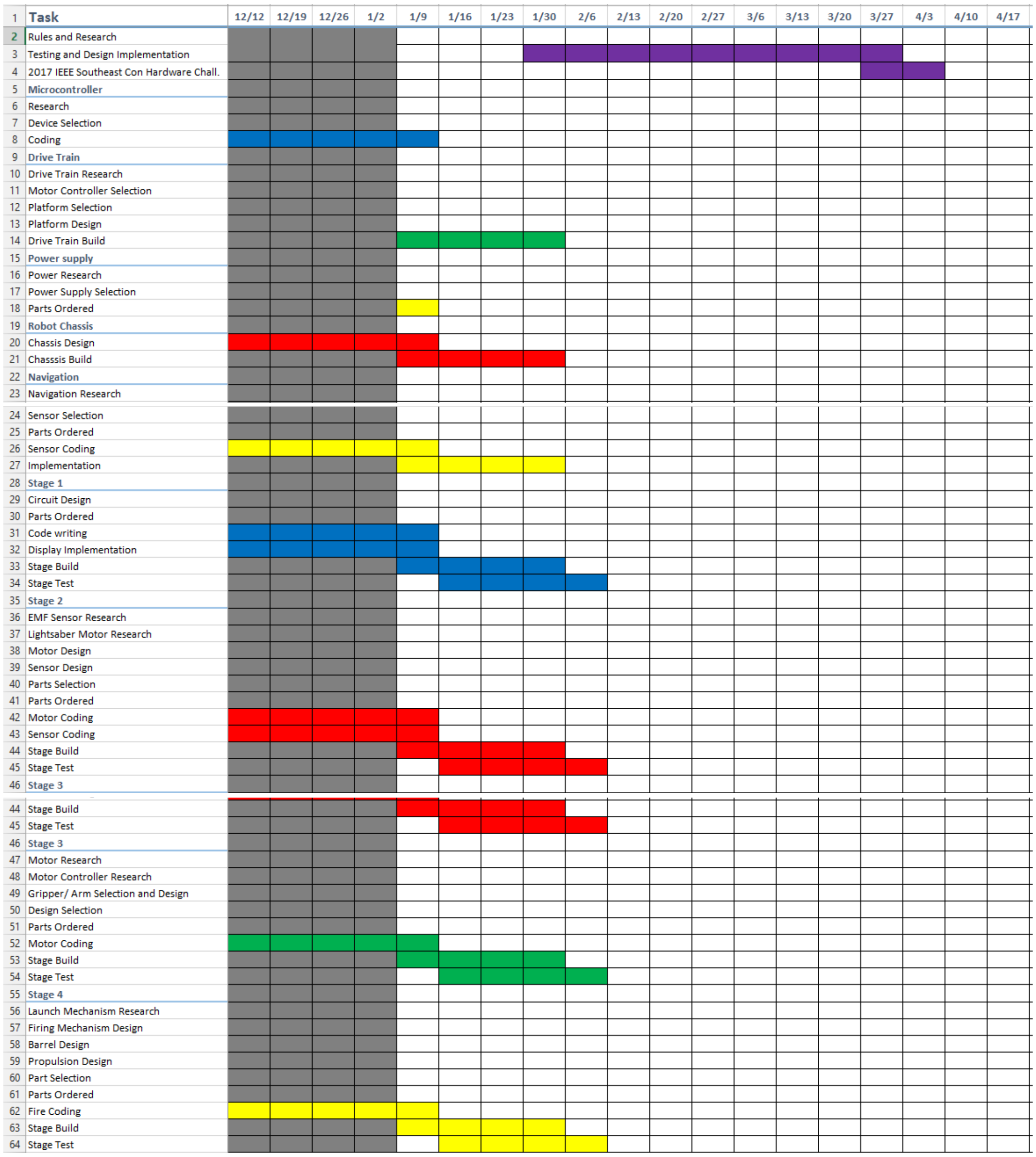
Tasks that need to be finished first include receiving the microcontroller, chassis design, and navigation. The microcontroller needs to be chosen in order to start testing code. The chassis design needs to be finished so we can start looking at the actual robot in the field. The navigation needs to be determined on order to decide how we are going to move autonomously from stage to stage. Without these three components, the robot will not even be able to make it to the stages to receive points.

Gantt chart

Work done before winter break.

1	Task	Lead	Start	End	9/12	9/19	9/26	10/3	10/10	10/17	10/24	10/31	11/7	11/14	11/21	11/28	12/5
2	Rules and Research	All	9/12	9/26													
3	Testing and Design Implementation	All	1/30	3/27													
4	2017 IEEE Southeast Con Hardware Chall.	All	3/27	4/3													
5	Microcontroller																
6	Research	Michael	9/19	10/24													
7	Device Selection	All	10/24	11/7													
8	Coding	Michael	12/5	1/9													
9	Drive Train																
10	Drive Train Research	Nicole	9/19	10/24													
11	Motor Controller Selection	Nicole	9/19	10/24													
12	Platform Selection	All	10/24	10/30													
13	Platform Design	Hunter	10/24	11/7													
14	Drive Train Build	Nicole	1/9	1/30													
15	Power supply																
16	Power Research	Michael	9/19	10/31													
17	Power Supply Selection	Michael	10/31	11/7													
18	Parts Ordered	Colin	1/9	1/9													
19	Robot Chassis																
20	Chassis Design	Hunter	11/7	1/9													
21	Chasssis Build	Hunter	1/9	1/30													
22	Navigation																
23	Navigation Research	Colin	9/19	10/31													
24	Sensor Selection	All	10/31	11/7													
25	Parts Ordered	Colin	11/7	11/7													
26	Sensor Coding	Colin	11/14	1/9													
27	Implementation	Colin	1/9	1/30													
28	Stage 1																
29	Circuit Design	Michael	10/24	10/31													
30	Parts Ordered	Colin	11/7	11/7													
31	Code writing	Michael	11/14	1/9													
32	Display Implementation	Michael	11/14	1/9													
33	Stage Build	Michael	1/9	1/30													
34	Stage Test	Michael	1/16	2/6													
35	Stage 2																
36	EMF Sensor Research	Hunter	9/19	10/31													
37	Lightsaber Motor Research	Hunter	9/19	10/31													
38	Motor Design	Hunter	10/17	10/31													
39	Sensor Design	Hunter	10/17	10/31													
40	Parts Selection	All	10/31	11/7													
41	Parts Ordered	Colin	11/7	11/7													
42	Motor Coding	Hunter	11/14	1/9													
43	Sensor Coding	Hunter	11/14	1/9													
44	Stage Build	Hunter	1/9	1/30													
45	Stage Test	Hunter	1/16	2/6													
46	Stage 3																
47	Motor Research	Nicole	9/19	10/31													
48	Motor Controller Research	Nicole	9/19	10/31													
49	Gripper/ Arm Selection and Design	Nicole	10/10	10/31													
50	Design Selection	All	10/31	11/7													
51	Parts Ordered	Colin	11/7	11/7													
52	Motor Coding	Nicole	11/14	1/9													
53	Stage Build	Nicole	1/9	1/30													
54	Stage Test	Nicole	1/16	2/6													
55	Stage 4																
56	Launch Mechanism Research	Colin	9/19	10/31													
57	Firing Mechanism Design	Colin	10/24	11/7													
58	Barrel Design	Colin	10/24	11/7													
59	Propulsion Design	Colin	10/24	11/7													
60	Part Selection	All	10/31	11/7													
61	Parts Ordered	Colin	11/7	11/7													
62	Fire Coding	Colin	11/14	1/9													
63	Stage Build	Colin	1/9	1/30													
64	Stage Test	Colin	1/16	2/6													

Work done after winter break



Task Assignment

Michael Pelletier – Team Leader

Manages the team as a whole; develops a plan and timeline for the project, finalizes all documents and provides input on other positions where needed. The team leader is responsible for promoting synergy and increased teamwork. If a problem arises, the team leader will act in the best interest of the project.

He keeps the communication flowing, both between team members and Sponsor. He is responsible for setting up appointments and making sure the team members are aware of said meetings. The team leader takes the lead in organizing, and planning. In addition, he is responsible for keeping a record of all correspondence between the group and 'minutes' for the meetings. Finally he gives or facilitates presentations by individual team members and is responsible for overall project plans and progress

Colin Fortner – Financial Advisor

Manages the budget and maintains a record of all credits and debits to project account. Any product or expenditure requests must be presented to the advisor, whom is then responsible for reviewing and the analysis of equivalent/alternate solutions. They then relay the information to the team and if the request is granted, order the selection. A record of these analyses and budget adjustments must be kept.

Hunter Fitch – Lead Mechanical Designer

Takes charge of the mechanical design aspects of the project.
They are in charge of the design of the robot chassis with motors and servos
He is responsible for knowing details of the design, and presenting the options for each aspect to the team for the decision process. Keeps all design documentation for record and is responsible for gathering all reports.

Nicole Perry – Lead Electrical Designer

He is responsible of the EE, IE, or CE design part in support of the project. He maintains line of communication with the lead ME. He keeps all design documentation for record.

All Team Members:

- Work on certain tasks of the project
- Buys into the project goals and success
- Delivers on commitments
- Listen and contribute constructively (feedback)
- Be effective in trying to get message across
- Be open minded to others ideas
- Respect others roles and ideas
- Be ambassador to the outside world in own tasks

Product Spec

Design Spec

This product is limited to one cubic foot of area. There is a limit of 30 PSI for firing of the nerf projectile, which if implemented, will be pressurized manually before each run. Tentative chassis design is a three tiered structure with the microcontroller and motor controllers on the first level. The circuit board and rotational servo for stages one and three respectively, as well as any distance sensors on the second level. The third level with consist of the EMF sensor and nerf firing mechanism for stages two and four respectively. The LED display will be mounted on the side of the robot for readout in stage one.

Performance Spec

The distance sensors used will need a maximum range of at least 36 inches. The battery on the design must be able to supply an input voltage to the microcontroller in a range of 7.2V to 12V constantly for a four minute period. The robot must run autonomously so error detection must be implemented in coding to correct any errors. Due to the fact that it is autonomous, accuracy of the sensors and positioning of the components is crucial to success. The smallest error in accuracy can ruin a run if not properly handled. Most power consumption will probably come from the EMF sensor in order to detect the field, however calculation needed to be made.

Conceptual Design

The design for our project is set to have the front and back of the robot to have two extensions each. Each extension will correspond to an individual stage of the competition. For stage one and three, the heights are at a fixed position that cannot be altered, due to this fact, it makes sense that these sensors be on opposite sides of each other. The light saber for stage two and the projectile launcher in stage four do not have designated locations so they can be mounted above the extensions for the previous two stages. The sides of the robot would be difficult to use with extensions due to the fact that we are using tracks and it would be unnecessary to approach an obstacle sideways as opposed to head on. For that reason, the sides of the robot will be used to monitor the display screens, distance sensors as well as the drive train of the robot.

Other designs that were considered for the build of the robot include a rotating platform that could change 90 degrees in order to have one extension on each side. However due to the fact that we have plenty of room vertically, this added complication was not necessary. Wheels were another option for our motion. It would have been just as easy to implement and design, with faster movement. However, the decision to use tracks was made for the purpose of stage four. The use of track makes climbing the stairs to get closer to the target.

Conclusion

This report describes the needs of the robot based on the April 2016 edition of the 2017 Southeast Con Hardware Challenge rules. The robot is tasked with completing four stages in an arena. The robot must navigate autonomously and will have sensors to determine its position in the arena. The three proposed movement trains are wheels, tracks, or legs. The first stage requires decoding a code by determining the components within a circuit. The code will be displayed on an LCD or LED screen. The second stage is a "lightsaber duel." Using an electromagnetic sensor, the robot will be able to process when an electromagnetic field is deployed. During this time, the robot will hit a lightsaber that contains a vibration sensor. The third stage has the robot turn a quadrature encoder using the code found in stage one. Either a continuous rotation servo or stepper motor will be used to turn the knob. Finally, stage four consists of launching nerf darts into a portal at the end of the arena. The match will take less than four minutes to complete. Points will be awarded for successful completion of each stage.

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