FAMU-FSU College of Engineering

IEEE Southeast Con Hardware Challenge 2017
Needs Assessment

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9/30/2016

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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.

<table>
<tr><td rowspan="4">Microcontrollers</td><td>Type</td><td>Cost</td><td>Advantages</td></tr>
<tr><td>Raspberry Pi</td><td>$40</td><td>TBA</td></tr>
<tr><td>Arduino</td><td>$25</td><td>TBA</td></tr>
<tr><td>MSP Launchpad</td><td>$20</td><td>TBA</td></tr>
</table>

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).

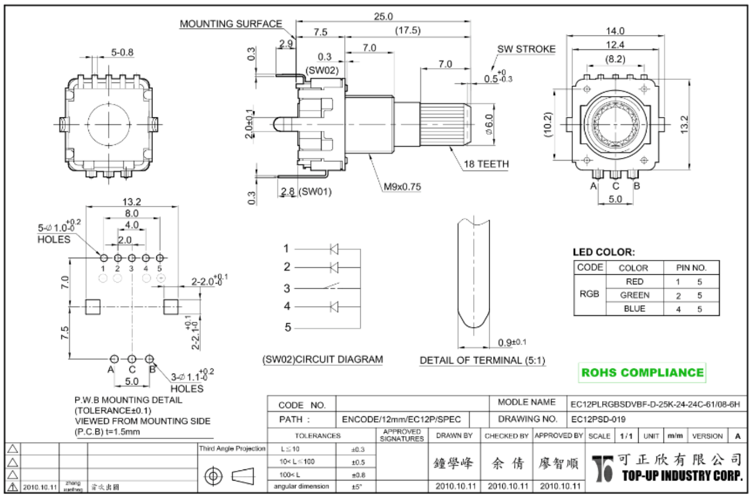

Figure 3: COM-10982 ROHS Data Sheet

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.

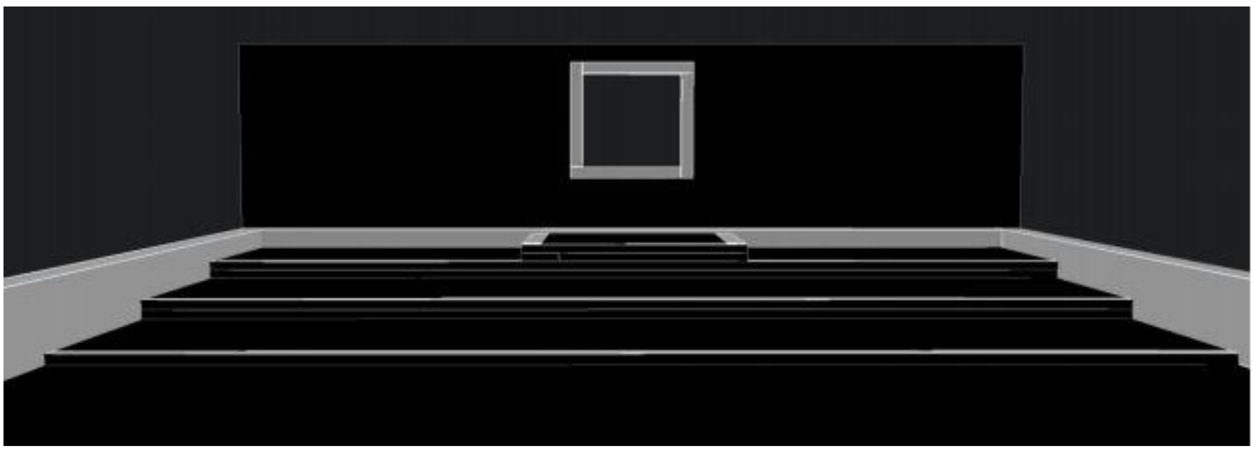

Figure 3: Arena Design

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).

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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