FEBRUARY 26, 2018

TEAM FALCON

SAN DIEGO STATE UNIVERSITY

MINI SUMO ROBOT

SENIOR DESIGN PROJECT PROPOSAL

TEAM MEMBERS

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John Kennedy

Table of Contents

List of figures 1
Introduction 1
  Abstract 1
  Project Description 1
Design 2
  Block Diagram: 2
  Mock-Up Illustrations: 2
  Performance Requirement 4
    Body dimension requirements. 4
    Mass & Aesthetic requirements. 4
    Torque & RPM requirements. 4
    Hardware requirements. 4
    Mode Requirements. 4
Testing Procedures: 4
  Reflectance & IR sensors. 4
    Testing on Sensors: 4
    Reflectance and Edge Sensors 4
  Motors & H-Bridges. 6
  Power Supply. 6
  Microcontroller: 7
  Benchmarks: 7
Project management: 7
  Project scope: 7
  Task delegation: 8
  Milestones: 8
Budget: 11
Promotional Flyer: 13

List of figures

Figure 1 - Block Diagram 2
Figure 2 - Bottom View 3
Figure 3 - Top View 3
Figure 4 - Side View 3

List of Charts

Chart 1 - Sharp Data 5
Chart 2 - QTR1A Black 5
Chart 3 - QTR1A White 6
Chart 4 - No Load 6
Chart 5 - With Load 6

Introduction

Abstract

Mini-sumo is a competition between two autonomous robots that are placed in a ring (Dohyo). The robots will then autonomously compete in a head-to-head match with the objective of forcing the opponent out of the ring. The designed robot, will have the ability to quickly detect the position of the opponent at the start of the battle and win the match by knocking the opponent out of the ring.

Project Description

When designing our robot, we adhered to the Robogames unified sumo rules. Robot-sumo is divided into various classes, with our robot particularly being the Mini-sumo. Our robot would have to weigh no more than 500 g mass, dimensions be 10 cm by 10 cm with any height and the budget limited to $500.

Although no actual "weapons" are allowed, most designs consist of an angled blade at the front of the chassis which is used to tilt over the robot and eventually push it off the ring. Using an IR remote, the robots are activated by the referee and with that the match begins.

Our ideology for the robot was for it to be agile in maneuvering within the ring not only to evade an opponent, but to also outsmart and push the opponent out. We set three different modes for our robot: Default, search and destroy, and the Falcon PUNCH! During the default mode, our robot's main objective will be to stay within the boundaries. The flexibility of having these three modes will allow it to adapt to any situation and/or opponent that may present itself. We chose to use two wheels for a simple design and have additional weight at the front of the robot to balance out the weight from the wheels in the back. We implemented a downward angled blade to be used to scoop up the opponent off the ground and eventually push the robot off the Dohyo. Most of our components will be placed within our chassis and will have multiple layers (PCBs) to route the wires from the bottom layer to the top where all the SHARP sensors will be connected. The motor drivers would sit on the top-level PCB then the reflectance sensors along with the motors would be mounted on top of the lower-level PCB.

SHARP GP2Y0A21YK0F analog distance sensors and QTR-1A reflectance sensors will be implemented in order to create a competitive robot. Four reflective sensors will be mounted on the four corners of the robot, allowing it to detect whether the surface under the robot is black or white thus preventing it from driving out of the ring. Four SHARP sensors will be placed on each side of the robot in order to detect where the opponent is at all times.

The decisions and functionalities of this autonomous robot will be controlled by The TEENSY 3.2 which has a super-fast 72 MHz Cortex-M4 processor. This microcontroller will mostly focus on monitoring the sensors and make decisions on where to go and when to turn depending on the results. The secondary function of the microcontroller is to drive the MAX14870 Single Brushed DC Motor Driver Carrier. The motor driver will, as a result, drive the two motors and allow for the robot to head left, right, forward or reverse.

In order to implement this design, the microcontroller must have at minimum twelve ADC pins for the sensors, two PWM pins for the motor drivers, and some other general-purpose input/output pins. This can be seen in (Figure 1) and is further explained below.

Design

Block Diagram:

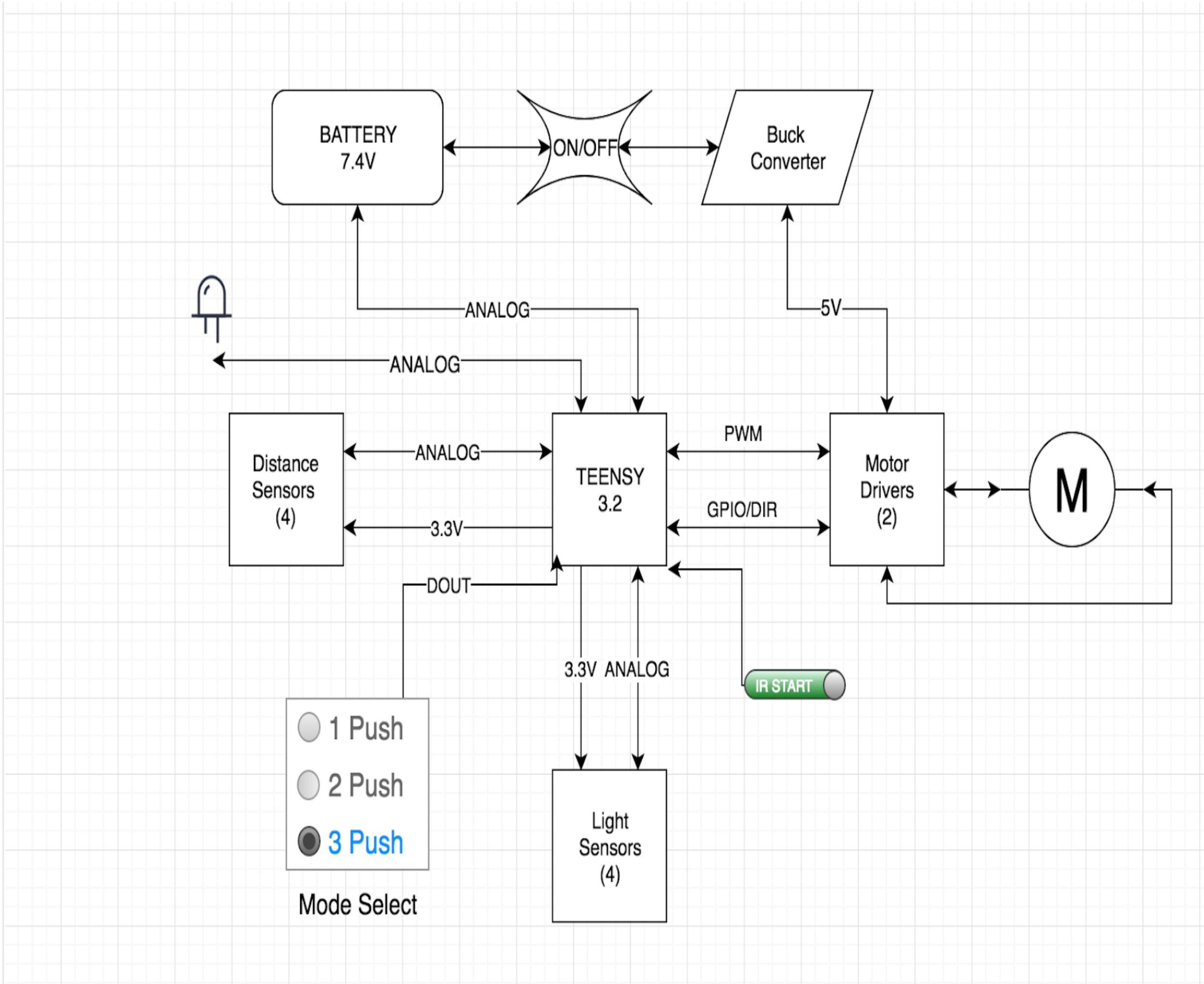
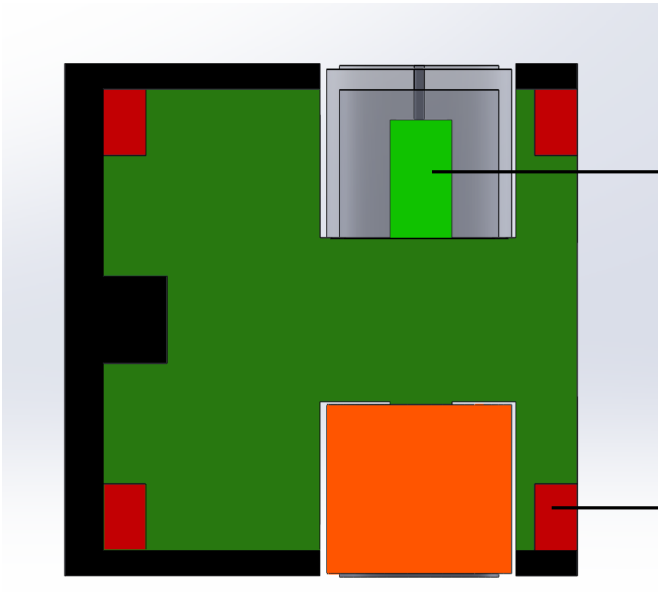


Figure 1 - Block Diagram

Mock-Up Illustrations:

For this part, we used Solid works to design our body structure. Using this tool allowed us to design each part individually and adding them together as shown in figures 2, 3, and 4.
The robot will be based on the main PCB colored in dark green as shown in (Figure 2), The main PCB will carry most of the components such as: edge sensors, motors, teensy microcontroller and the H-bridges. The top and side view shows the second level PCB colored in light green that will connect the IR sensors, LEDS and Pushbutton as shown in (Figure 3 & 4).



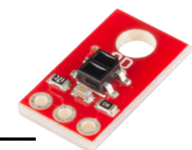


Figure 2 - Bottom View

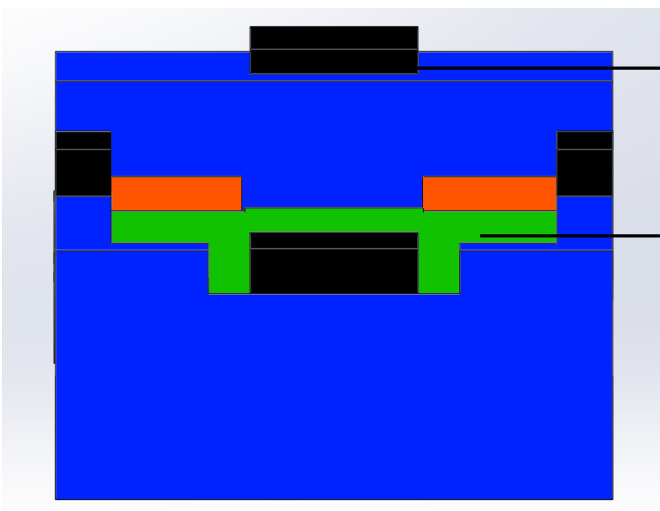
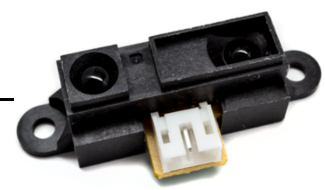
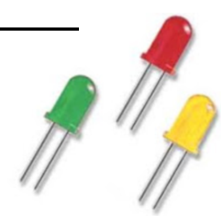




Figure 3 - Top View

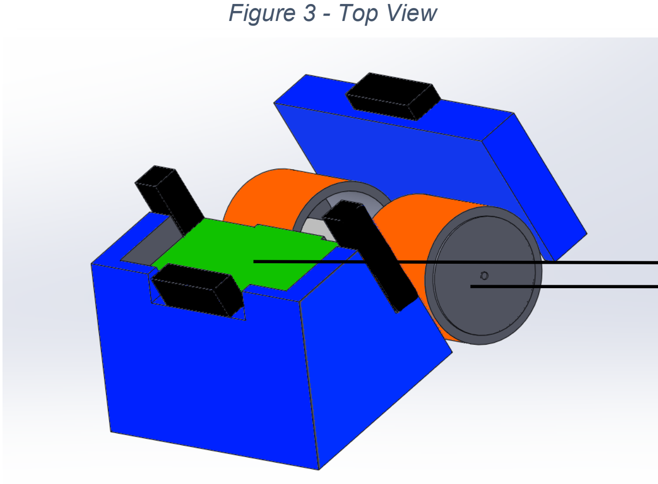


Figure 4 - Side View

Performance Requirement

Intended features: Quick, smart, agile, and enough torque to hold its ground.

Body dimension requirements.

The Mini-Sumo robot is restricted to a weight of no more than 500 g as well as a length and width of 10cm.

Mass & Aesthetic requirements.

The combination of the chassis of the sumo robot, wheels, and hardware components are not intended to weigh a total of 500 g, so extra weight is going to be added at the lower & front end of the chassis. The wheels are 37mm for high agility as well as medium-high torque levels to maximize efficiency.

Torque & RPM requirements.

With the intended robot's characteristics, the middle ground for the torque and RPM is going to be met. Torque is expected to be 15 oz.-in and around 600 RPM at stall condition, which will output around 0.11 kW of power.

Hardware requirements.

The IR sensors & microcontroller should be supplied with 5V through the voltage regulators. The PCB being an essential part of the chassis (bottom base), where it will be the skeleton of the sumo robot minimizing wires.

Mode Requirements.

- First mode:
  - Safe mode (default) – stay within a ring, evade when encountering an opponent.
- Second mode:
  - Attack mode – when the front IR sensors detect an opponent, the robot will be in the attack mode.
- Third mode:
  - **FALCON PUNCH** (full offense mode, all or nothing).

Testing Procedures:

Reflectance & IR sensors.

Testing on Sensors:

The sensor that we have chosen to go with are Sharp GP2Y0A21YK0F and QTR-1A reflectance sensors.

Reflectance and Edge Sensors

Our sumo robot is meant to be a stable machine that will be able to detect objects quickly and make quick decisions on the position of the enemy, while staying within the ring of combat. For our standards we chose to have both our sensors output analog signals, this way the received values, from the sensor to the microcontroller can be distinctly programmed for the situation. First, the reflectance sensor we chose is the Sharp GP2Y0A21YK0F, which also gives us an advantage for computing distance as well. How we tested the Sharp sensor was by using our microcontroller's ADC to print out the analog values based on the change of voltage to a serial monitor. We then recorded these values for analysis in chart 1, we can see that the sensor has a valid analog read of the voltage at around or near 5cm, which will be accounted for when we mount it on the robot.

For our edge sensors we went with the analog QTR-1A for varying techniques for different values. That way our robot will not be fooled by fake edges. We recorded our data by using a black tape and white paper by varying the distances. We then recorded the data printed out to the serial monitor of the ADC values which ranges from zero to 1023.

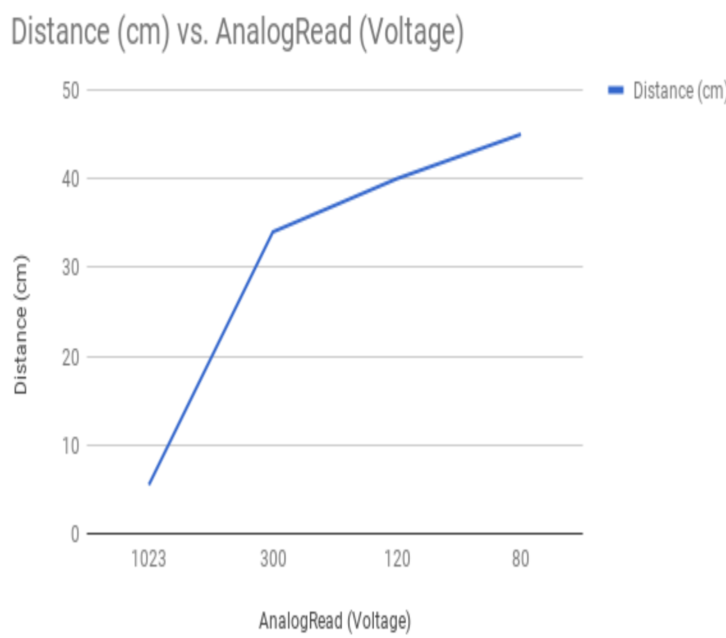


Chart 1 - Sharp Data

In the chart above we have a drop off when the black is too close and too far, so the height of our sumo-robot must be within 1.5 - 2.5 cm off the ground. This way we can get more accurate readings. The results above, in chart 2 correlate to chart 3 below, for the white color. In chart 3, we can see that the QTR-1A detects white when it is with 0cm to 2cm before the voltage difference of the varying ADC values begin to drop. This will be highly useful for detecting the edge because the ring has a white tape around the circle.

The sensors met our expectations for our sumo robot, and we will be able to implement varying strategic techniques based on our sensor values to fight the enemy sumo robot.

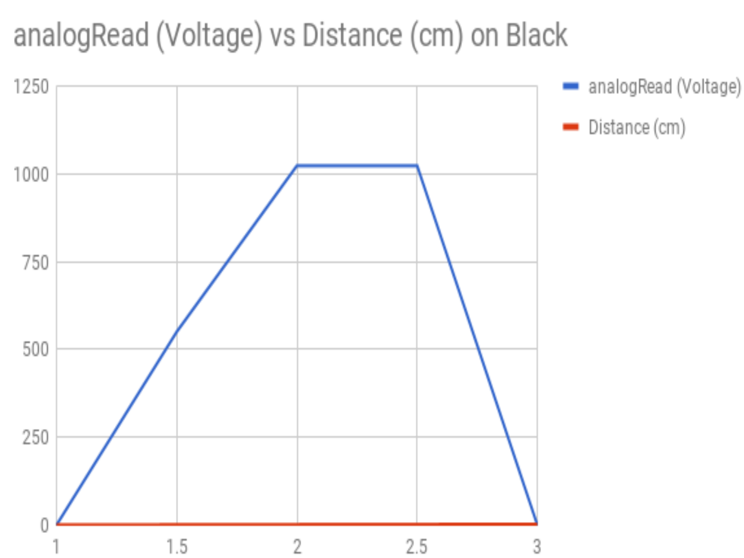


Chart 2 - QTR1A Black

Other tests we could have done would be physical stress tests or prolonged use under varying voltages. However, our tests will be good enough for our application since the sumo robots will not be generating much force.

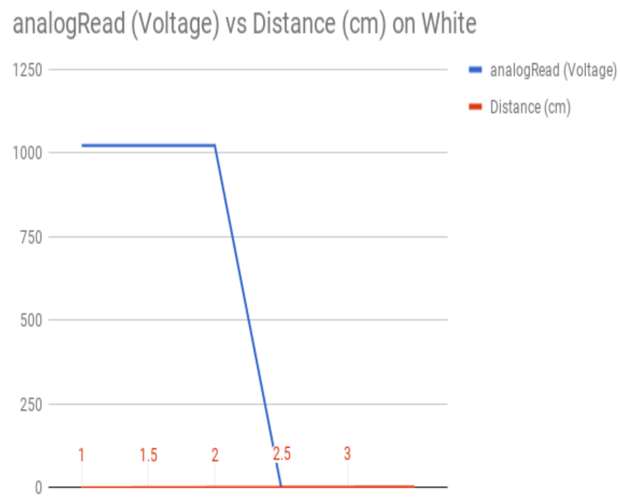


Chart 3 - QTR1A White

Motors & H-Bridges.

The first step was to test the component performance to check and verify that they will meet our requirements. A tachometer was used to measure the speed of the motors in RPM under a no load/load condition. The first test we connected the motor to the power supply, and set the power supply at 1.6 A stall current and started at 1V raising gradually till we reached 8V. The second test was done with load, where we tested the ties on a wood board to create some friction, and with load as predicted we will have less RPM. However the results came back better than expected. Even though it is a 6V motor, when testing on 8V we thought that might damage the H-bridge, but that did not happen and everything continued running smoothly. After collecting the data from both tests with load and no load, the results matched what we expected to get**.** The results can be seen in the charts below.

Power Supply.

Power supply module is around 8V, considering the robot motors speed and torque requirements. The designed sumo robot will have a single battery which has advantages of being easy to replace, and lightweight.
LiPo battery of 7.4V nominal voltage and 600mAh is going to be implemented into the sumo robot construction, since it is relatively lightweight, has a good capacity, as well as a high discharge rate. With the given battery specs and workload, such as supplying 7.4V as well as around 1.2 A to the pair of motors, it is expected to power the sumo robot for 15-20 min.

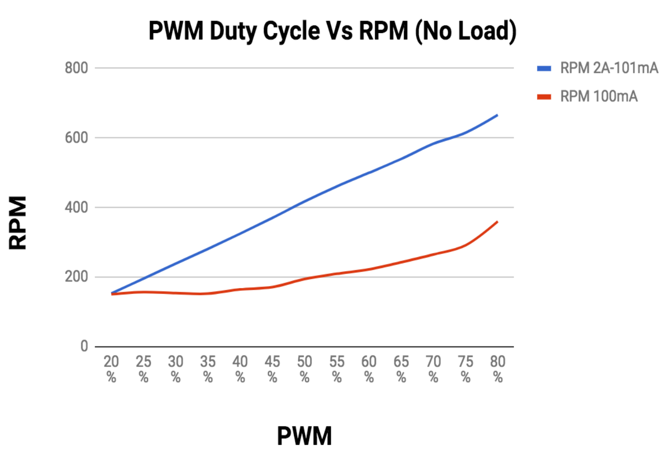


Chart 4 - No Load

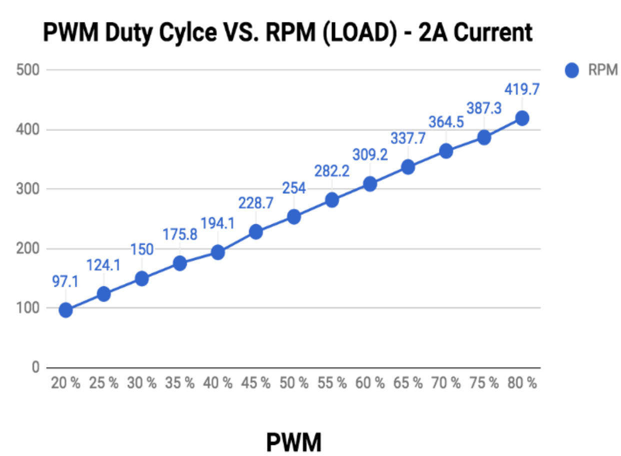


Chart 5 - With Load

Microcontroller:

The code will be written in the C language and we will be implementing primarily with the Teensy 3.2. We also have in mind to implement with the PIC32 (SDIP or QFN?) once we finish a working proto-type with the Teensy 3.2. Once we collect data from our sumo-robot we will adjust our code and the features it will have.

Our robot will have multiple battle modes to tackle our opponents and adapt to their playing style. This will be hard work when trying to be efficient in the length of code written. We want our robot to have a small file size of code so that it will be able to execute instructions fast. We will be using interrupts for our edge sensors, but the opponent sensors (IR) will be constantly read and based on the output values, that will impact what our robot does. Since we only have two wheels for a heavy tank-style of aggression, our robot will be able to pivot fast and evade the enemy from direct attacks.

In the code, we have specified and recorded the ADC values in which we want to set the flags for the motors duty cycle PWM. That way, our robot will be able to respond with the ever-changing analog signals like a real-time system.

We will also have smaller features like blinking LEDs to determine sensor reads and direction turns of the motors. We will also have features for debugging the code, that way we won't have to consistently rewrite it.

After Teensy 3.2 testing, we will try to implement the code and configure it onto a PIC32 for additional testing if needed and improve the code from the original design. This way we can ensure a much more stable robot with robust code to boot.

Benchmarks:

In order to determine when the project is operating satisfactory, we divide the benchmarks into three stages.

- Stage 1
  - The ability to sense the starting signal and react accordingly.
- Stage 2
  - The ability to detect the opponent quickly and efficiently.
- Stage 3
  - The ability to attack and overload an opponent that is 500 g, paired with a high torque ratio. A strong chassis structured around a strong PCB design.

Project management:

Project scope:

Our goal is to design a mini sumo robot, weighing 500g, and being operational to battle other team's robots. The mini sumo robot is a very flexible project allowing for a variety of possible designs, parts used, and strategies used in battle. This project is intended to be completed by the end of spring 2018 semester. Being the winning team allows us to showcase the skills we have learned throughout our educational career at San Diego State University, plus bragging rights amongst the other COMPE 496B groups. With the end goal being able to present a winning robot at senior design day, for the SDSU community to admire. Under the supervision of Professor John Kennedy, we meet weekly to discuss project performance, parts, designs, and learn how to conduct ourselves as part of an engineering team. The team members all chose one specific responsibility to oversee throughout the semester. Although we are by no means only limited to our specific role but required to work together like a well-oiled machine. We have been meeting weekly on Friday without Professor Kennedy to discuss weekly goals achieved and set new deliverables. Our mini sumo robot needs to be smart vs. fast, this relies heavily on good programming techniques with our microcontroller. We have selected a 50:1 HPCB micro-metal gear motor that will deliver around 600 rpm depending on the total load. The design team mocked up several designs for the robot body within the first two weeks and now we have a concept for the Punch I. In our weekly discussions we concluded that we would like our PCB to hold all electronic components and slot into the body effortlessly. Minimizing loose wires and keeping the design compact. Our PCB and 3D models should be finished before spring break (3/24/18). The team will begin testing and troubleshooting by the second week of April to allow the team to evaluate our results. Competition day will be 4/30 or 5/1 and this is when our semester long project will be showcased during the battles.

Task delegation:

Part testing – Motor 50:1 HP micro-metal gear motor (Layth & Mohammed)
IR + edge sensors (Royce & Linh)
Programming – Microcontroller [PIC32 or Teensy 3.2] (Royce & Linh)
3D design – Finished 3D models of draft concept for Punch I (Aziz & Linh)
Gantt chart & Block diagram – Outlining milestones and benchmarks for project (Greg)
Budget analysis – Outlining the costs allocated to fund our project (Layth)
PCB design: Designing a PCB that will hold all components and reside in the robot (Vic & Linh)
Flyer: Design a printed flyer showcasing our robot and team (Aziz)

Milestones:

1/29 - First meeting (project tasks delegation)
2/2 - Chosen parts for Punch I (mechanical and electronic parts)
2/5 - Second meeting (Order parts, discuss with John)
2/9 - Robot I designed (SolidWorks model)
2/12 - Third meeting (Review designs, discuss pros/cons)
2/16 - Part testing analysis reports, finalize Punch I design
2/19 - Fourth meeting (success/failures with parts)
2/26 - Fifth meeting. *PROJECT PROPOSAL DUE*
3/5 - Oral presentation
3/9 - All parts ordered *MILESTONE 1*
3/16 - Completed concept *MILESTONE 2*
3/23 - Finished PCB *MILESTONE 3*
4/13 - Falcon Punch I complete *MILESTONE 4*
4/27 - Punch I competition ready *MILESTONE 5*
4/30 & 5/1 - Formal presentations
5/2 - Engineering Design Day

Tasks

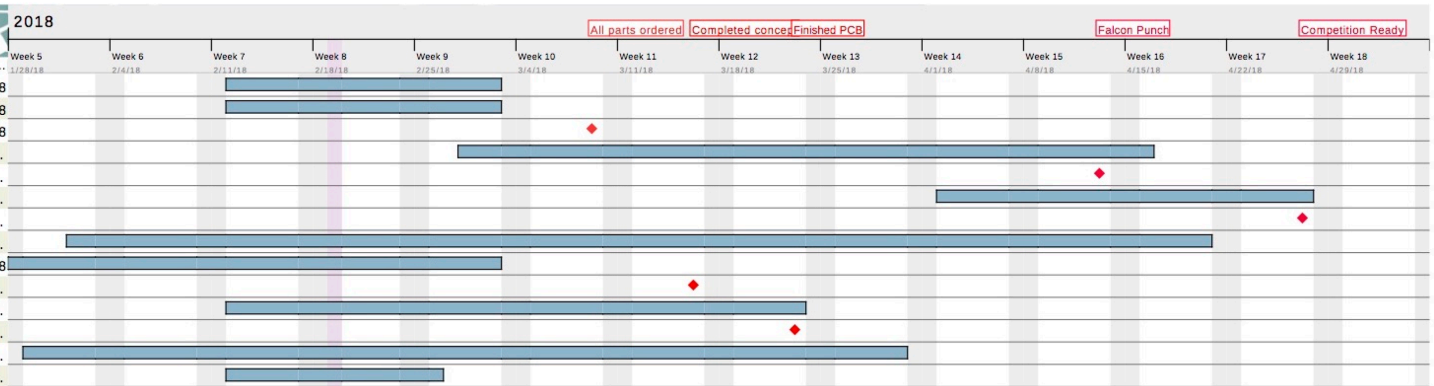
Name	Begin date	End date
Motor Testing	2/12/18	3/2/18
Sensor Testing	2/12/18	3/2/18
All parts ordered	3/9/18	3/9/18
Robot Testing	2/28/18	4/16/18
Falcon Punch	4/13/18	4/13/18
Troubleshooting	4/2/18	4/27/18
Competition Ready	4/27/18	4/27/18
Programming	2/1/18	4/20/18
3D model design	1/26/18	3/2/18
Completed concept	3/16/18	3/16/18
PCB design	2/12/18	3/23/18
Finished PCB	3/23/18	3/23/18
Budget	1/29/18	3/30/18
Project Proposal	2/12/18	2/26/18

Senior Design Project

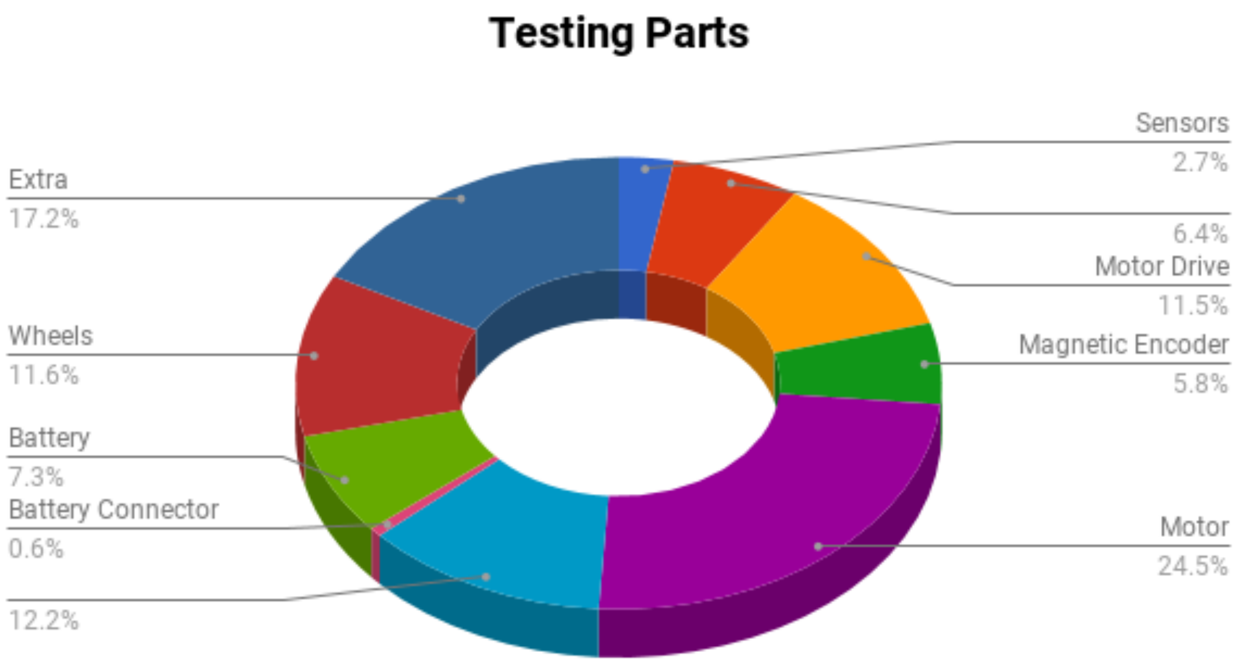
Feb 25, 2018

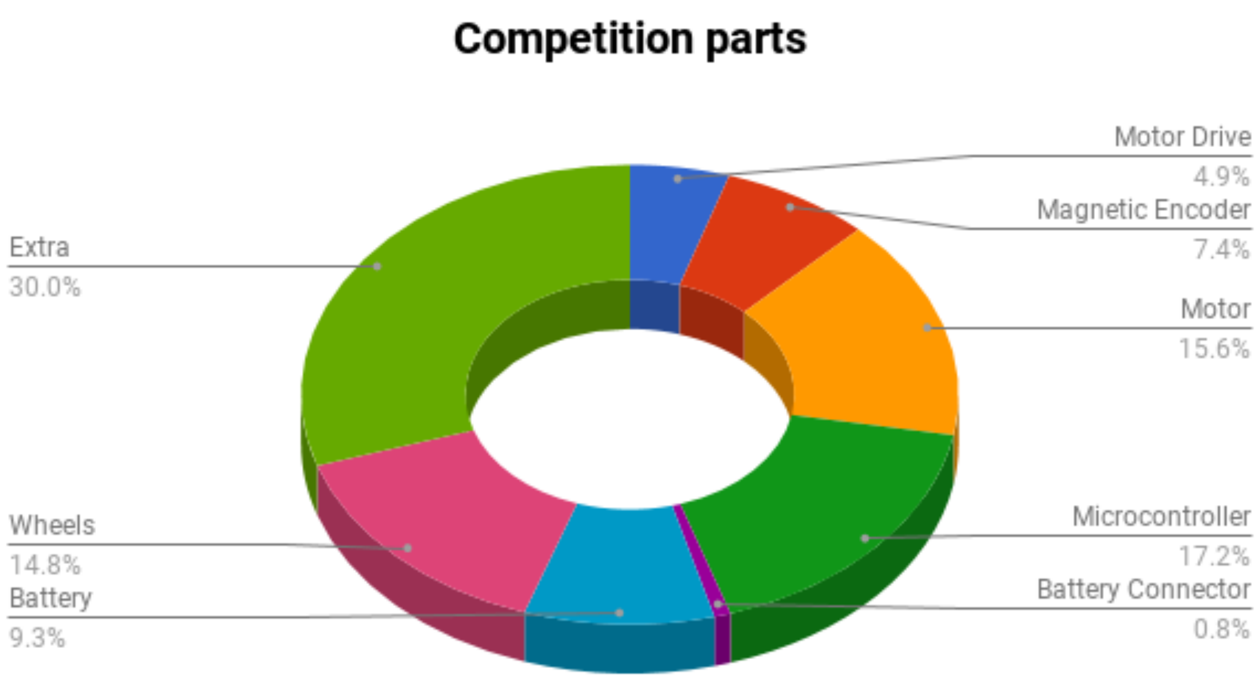
Gantt Chart

Name	Begin...	End d...
Motor Tes...	2/12...	3/2/18
Sensor Te...	2/12...	3/2/18
All parts ...	3/9/18	3/9/18
Robot Te...	2/28...	4/16...
Falcon Pu...	4/13...	4/13...
Troublesh...	4/2/18	4/27...
Competiti...	4/27...	4/27...
Program...	2/1/18	4/20...
3D model...	1/26...	3/2/18
Complete...	3/16...	3/16...
PCB design	2/12...	3/23...
Finished P...	3/23...	3/23...
Budget	1/29...	3/30...
Project Pr...	2/12...	2/26...



Budget:


Testing Parts
Sensors
2.7%
6.4%
Motor Drive
11.5%
Magnetic Encoder
5.8%
Motor
24.5%
Extra
17.2%
Wheels
11.6%
Battery
7.3%
Battery Connector
0.6%
12.2%


Competition parts
Motor Drive
4.9%
Magnetic Encoder
7.4%
Motor
15.6%
Microcontroller
17.2%
Battery Connector
0.8%
Extra
30.0%
Wheels
14.8%
Battery
9.3%

Budget	$500
Total Cost	$473.82
Remaining Budget	$26.18

- First round of purchasing consisted of purchasing 1 pair of wheels, 2 different motors, 1 battery, 1 battery connector, 1 magnetic encoder, 3 motor drivers, and 2 types of sensors (analog distance, and reflectance).

- After testing each part, another order will be placed for parts that will be used in the final design.

Promotional Flyer: