Team 22: Autonomous Ground Vehicle Design for Intelligent Ground Vehicle Competition

Midterm Presentation 1

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Overview

- Introduction
  - Intelligent Ground Vehicle Competition
  - Competition Objectives
  - Design Constraints
- Team Dynamics
- Challenges
- Work Distribution
- Prototype Design
  - Electrical Design Concepts
  - Mechanical Design Concepts
- Budget Breakdown
- Conclusion/Future Work

Intelligent Ground Vehicle Competition (IGVC)

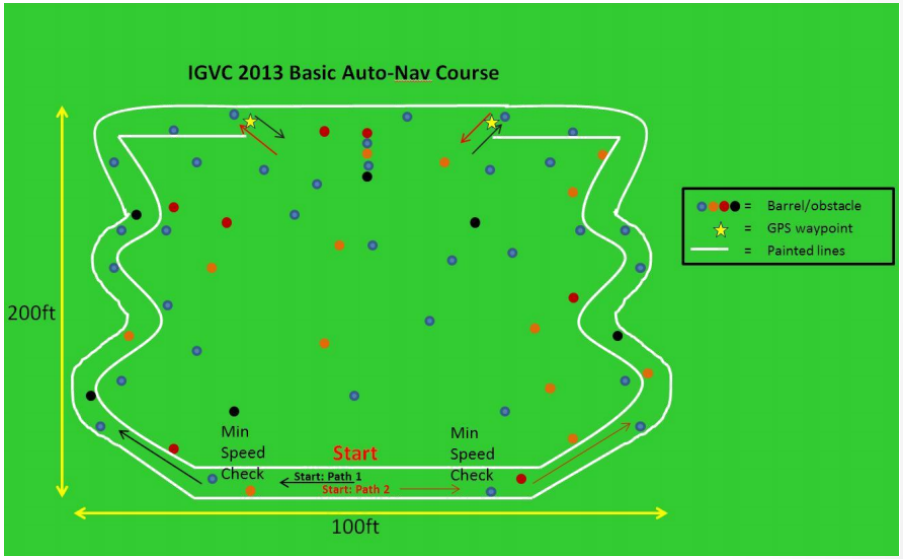
- Annual design competition held by Oakland University in Rochester, Michigan since in 1992
  - This years competition is June 3rd
- Provides hands on experience
- Focuses on latest technological advancements
- Team development
- Inside view of industrial design
  - Team members in remote locations
  - Communication

An autonomous vehicle competing in the IGVC

Competition Objectives

The AGVs are required to navigate an outdoor obstacle course that is recycled every 3 years

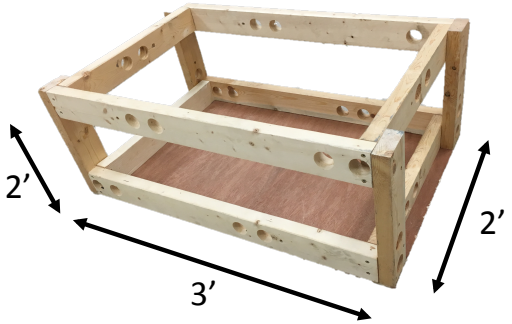
- under 15 minutes
- Within speed restrictions
  - (1~5 mph)
- Remain in lane
- Waypoint Identification
- Avoid Obstacles

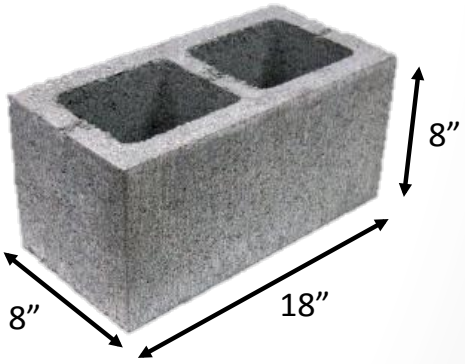


Layout of 2013 IGVC basic course

Design Constraints

- Dimension:
  - Length: 3~7 ft.
  - Width: 2~4 ft.
  - Height max: 6 ft.
- On board Battery Power
- 1 ~ 5 mph speed
- On Board and Wireless Emergency Push Stop
- Safety light
- Payload: 20lb (18” x 8” x 8”)





Team Dynamics

- Multidisciplinary Cross-Collaboration
- FAMU-FSU College of Engineering (COE)
- Junior FIT Team (Melbourne, FL)
  - 2 year project
- Working toward the common goal of qualifying and competing in IGVC
- Biggest challenge is communication

AGV attempting to avoid an obstacle

Challenges

- Starting from scratch
- FAMU/FSU-FIT Collaboration
  - Distance teamwork
  - Meshing Computer/Electrical and Mechanical Engineers
  - Coming to sound decisions
- Familiarizing with unexplored technologies
- Availability of Products
- Time Constraints

Work Distribution

FAMU/FSU

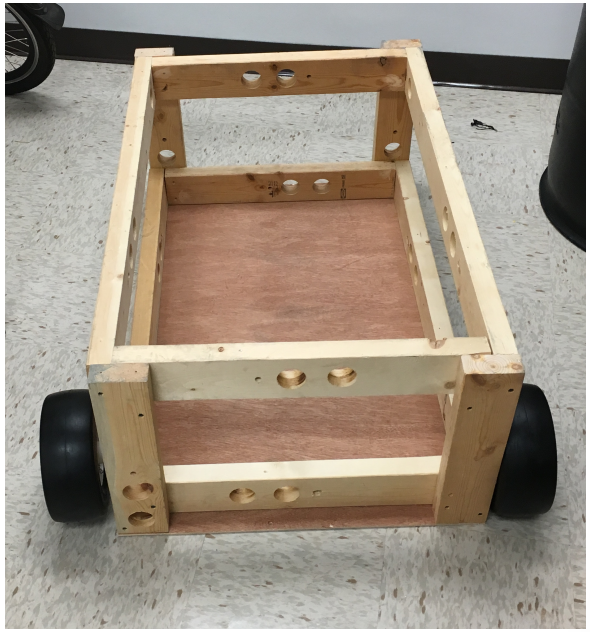
- Structure Fabrication
- Vehicle Speed Control
  - Maintain speeds of 1~5 mph
- Emergency Stops
  - Wireless and Mechanical
- Battery Selection

FIT

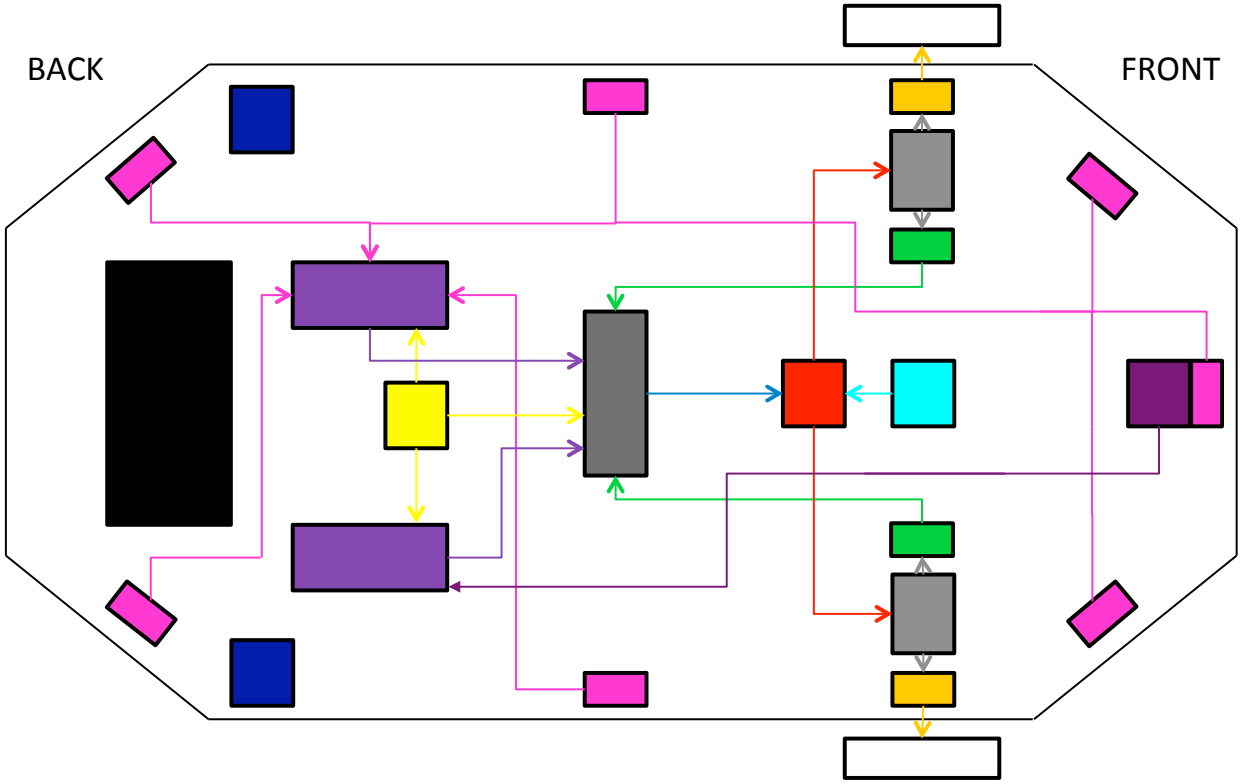
- GPS Waypoint Navigation
- Vehicle Perception
  - PixyCam
  - NVidia Jetson
  - Project Tango

Vehicle Prototype

- Structure from 2”x4” boards and 1/8” plywood
- Components can be mounted with ease
- Allows the frame to be fine-tuned before aluminum frame is machined



Block Diagram

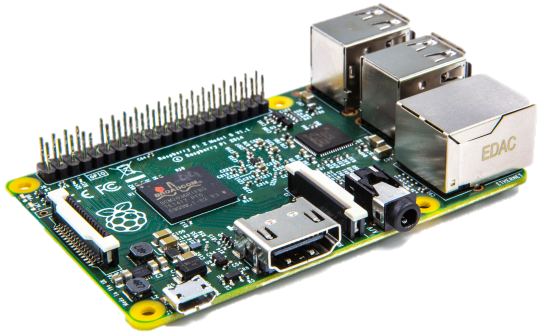


- Raspberry Pi 2
- MyRio NI 1900
- Motor Driver
- Motor
- Gearbox
- Driver Wheel
- Encoder
- Caster Wheels
- Xbee Module
- Pixy Camera
- Lidar System
- Payload
- Battery

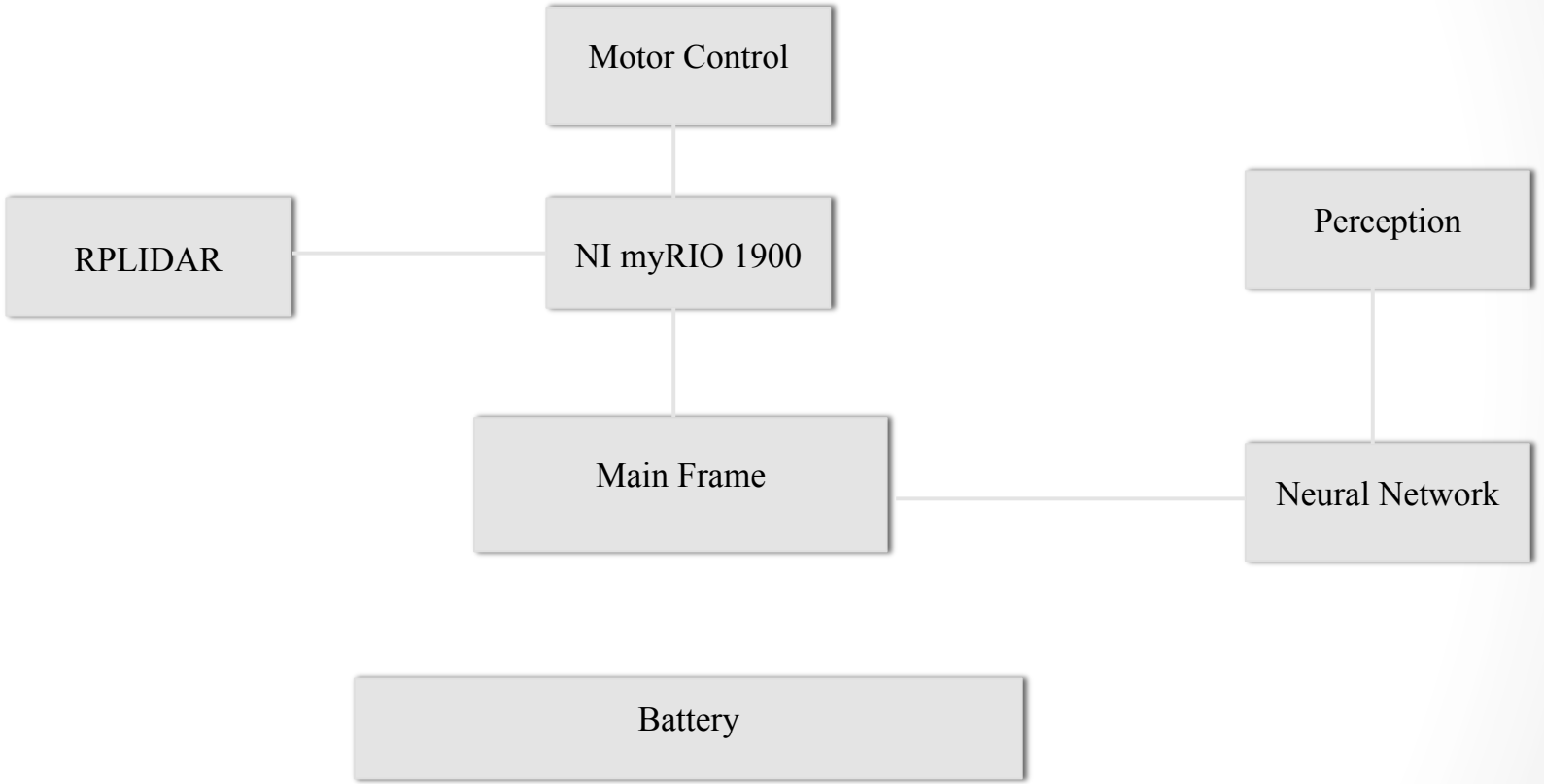
COE Electrical Design

- Block Diagram
- Fail safe Mechanism
  - RP Lidar
- Power
- Wireless Emergency Stop
  - Xbee

NI MyRio (above) and Raspberry Pi 2 B+ (below)



Block Diagram



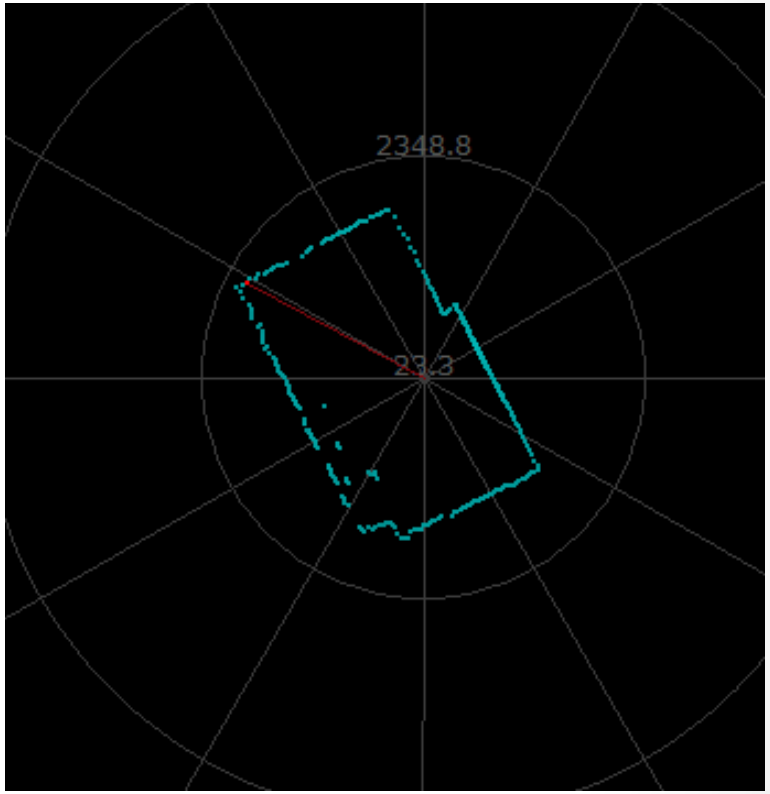
Fail Safe Mechanism

RPLidar

- Emitted modulated infrared laser signal is reflected by the object to be detected
- Built-In vision acquisition will sample the returning signal
- Embedded DSP will process the sample data using a start flag, quality.
- Distance value and an angle value between the object and the LIDAR will be outputted to a 2D plot

RPLidar Testing Scan 1

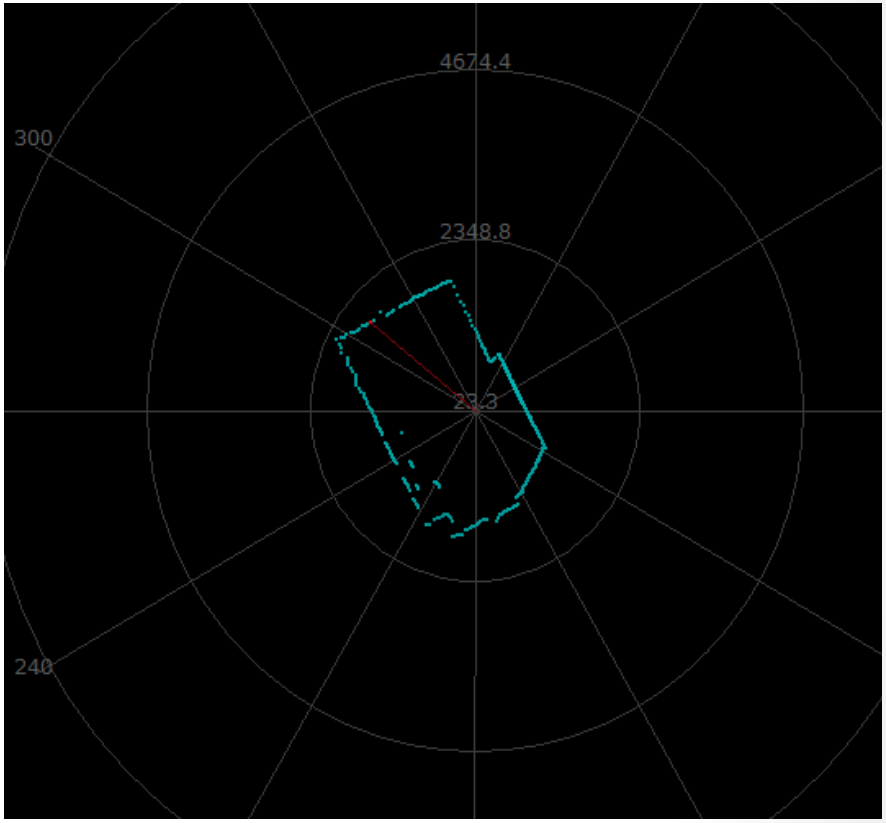
Real-world view of original room



2D plot of real-world view of original room

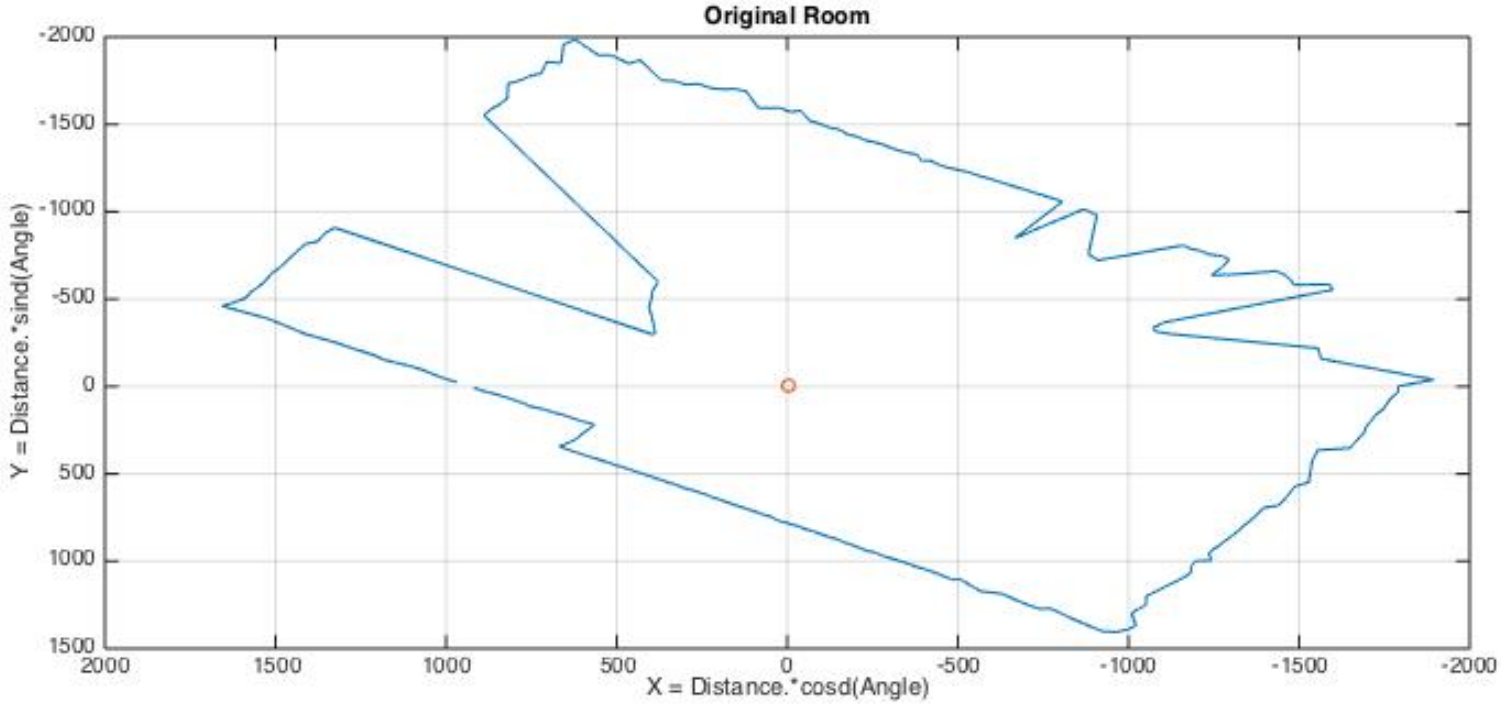
RPLidar Testing Scan 2

Real-world view of room with obstacle



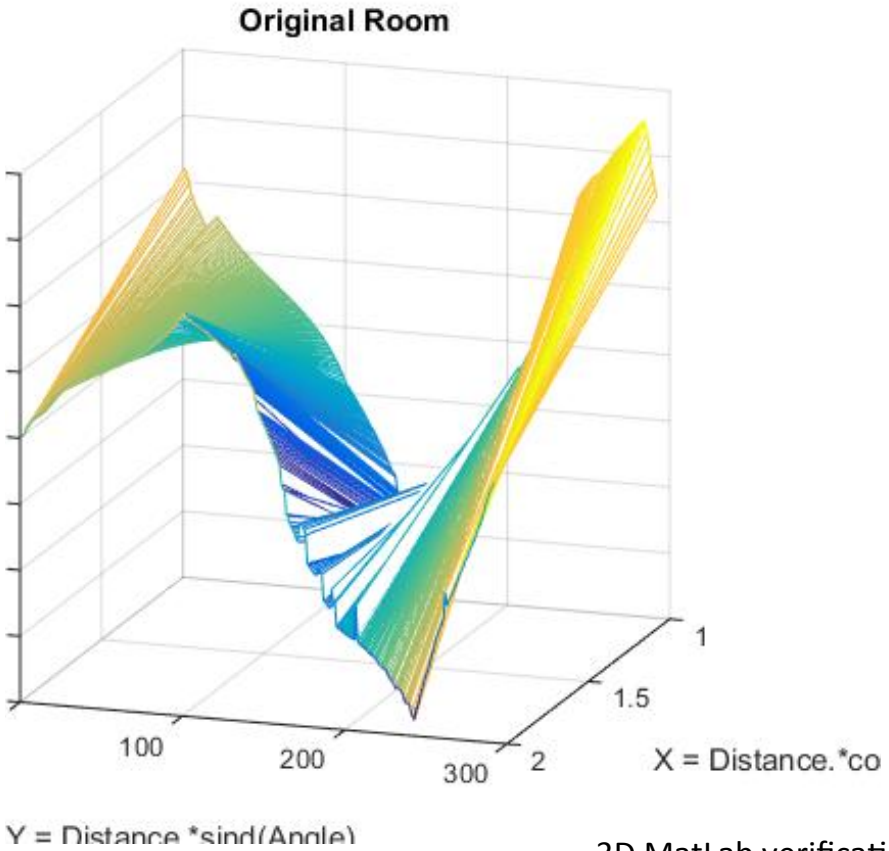
2D plot of real-world view of room with obstacle

RPLidar Analysis



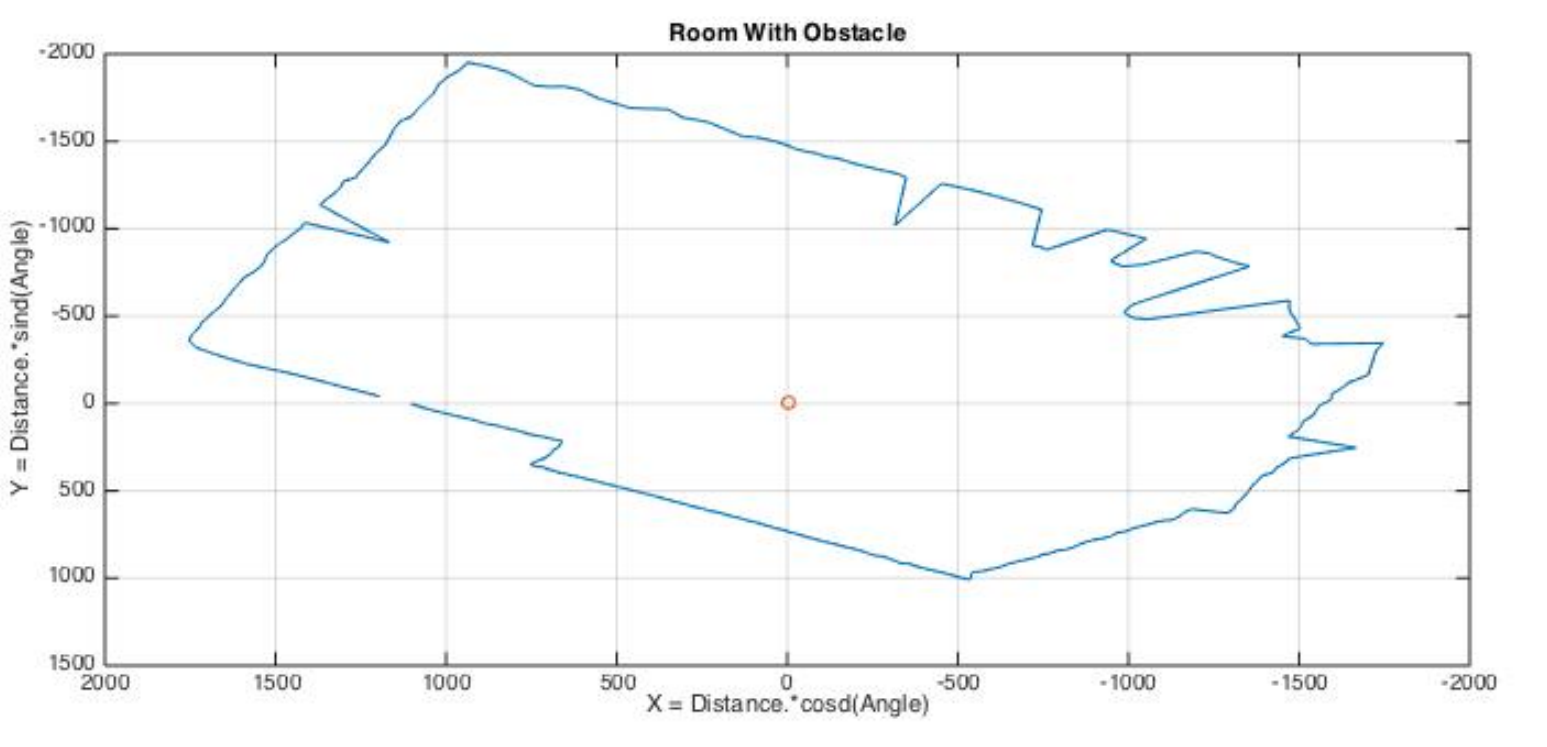
2D MatLab verification analysis of original room

RPLidar Analysis



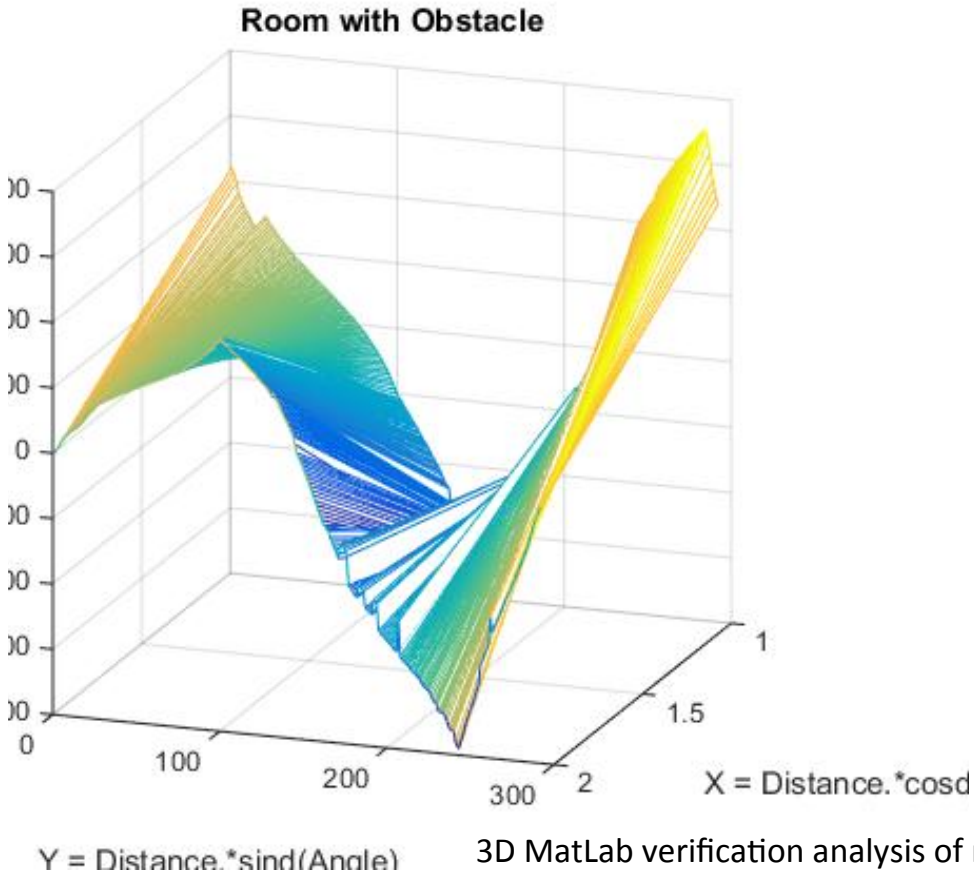
3D MatLab verification analysis of original room

RPLidar Analysis



2D MatLab verification analysis of room with obstacle

RPLidar Analysis



3D MatLab verification analysis of room with obstacle

Power

Safety Concerns

- Overcharge
- Over-discharge
- Short-Circuit
- Over Temperature

Lithium Ion Polymer Batteries

- More resistant to overcharge.
- Lower rate of self-discharge
  - Stored Charge of the battery is decreased at a lower rate.
  - Increased shelf-life

Distribution:

- Motor : 12 V ~ 15 V
- Cooling Fans: 12 V
- myRIO: 6 V ~ 16 V

Competition Constraint

- No combustion engines

Power

SeaVax Lithium Polyemer 12V Battery

- 4 hours of operating time
- Rechargeable
- Built-In ON/OFF switch for power save
- Weight: 340g (0.75 lbs)
- Capacity: 9800 mAh (9.8 Ah)
- Type: DC
- Input voltage: 12.6 V
- Output voltage: 10.8 V ~ 12.6 V
- 2A constant draw current (~48 W power)

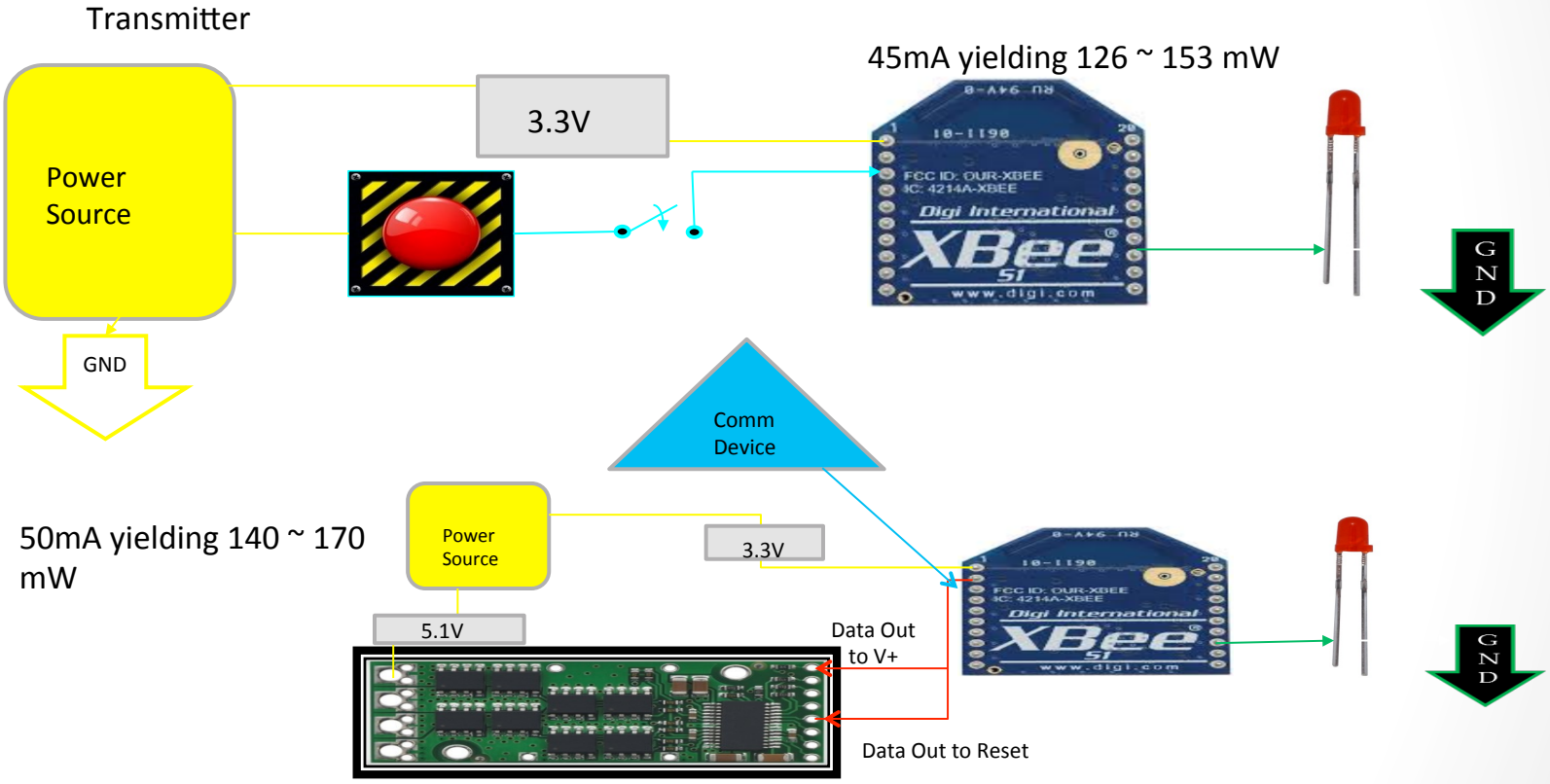
SeaVax Lithium Polymer 12 V Battery

Emergency Stop Device

Xbee 802.15.4

- Multipoint wireless networking RF
- 2.4 GHz operating frequency
- 300 ft. range
- 45mA transmit current, 50 mA receive current
- 3.3 operating voltage
- 250k bps
- -92 dBm receiver sensitivity

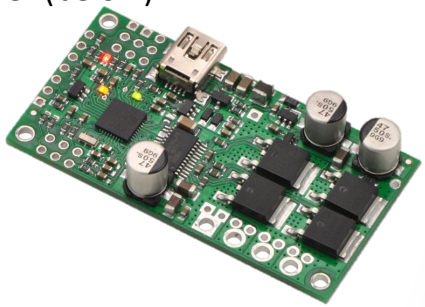
Emergency Stop Connection Diagram



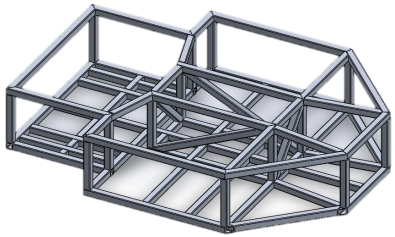
COE Mechanical Design

- Evolution of Frame Design
- Open Loop Speed Control Setup
- Components of Speed Control Setup
- Speed Control Testing
- Speed Control Analysis

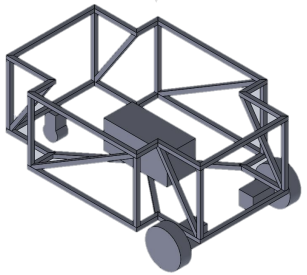
PG27 gear motor (above) and Pololu Motor Controller (below)



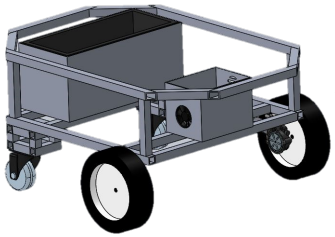
Evolution of Frame Design



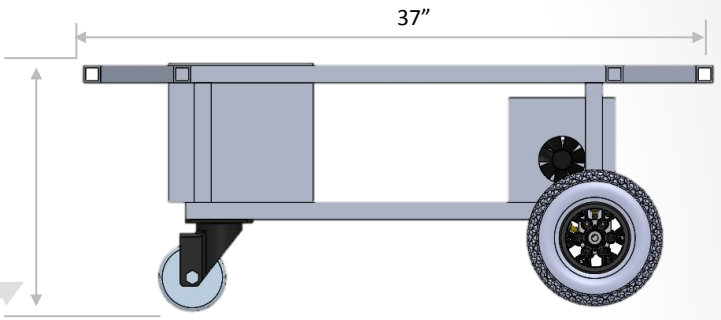
Initial Design



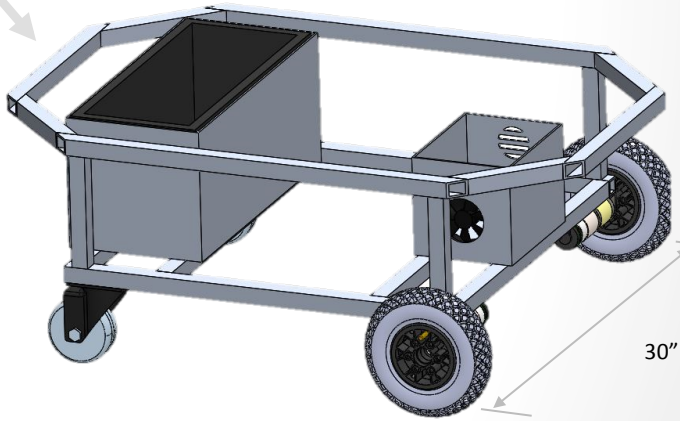
Intermediate Design 1 (Revision 1)



Intermediate Design 2 (Revision 2)

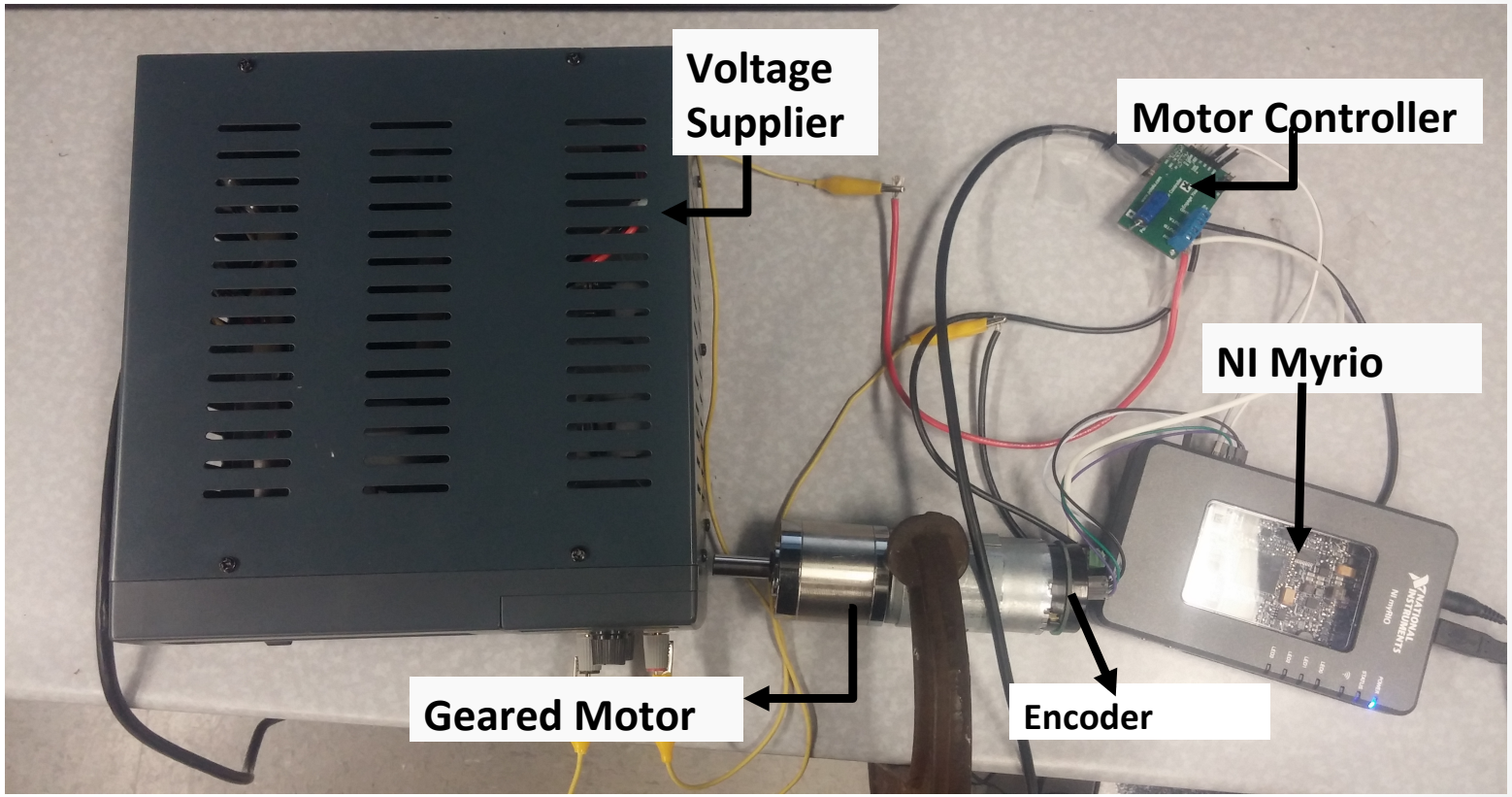


Final Design Side (Revision 3)



Final Design (Revision 3)

Open Loop Speed Control Setup



Components of Speed Control Setup

Microcontroller – NI Myrio

- Connects to the motor controller serially.
- Communicates to the motor-controller via Universal Asynchronous Receiver and Transmitter (UART).

Motor controller

- Has a variable baud rate (rate of signal change per secs) of 9600.
- Has a Pulse Width Modulation (PWM) of 21.77kHz

Encoder

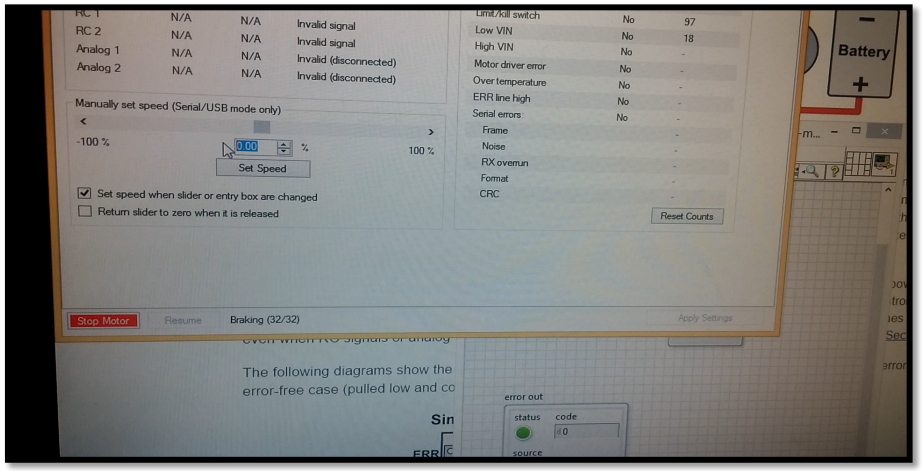
- Has 7 pulses per revolution and it's quadrature, equivalent to 28counts/revolution.

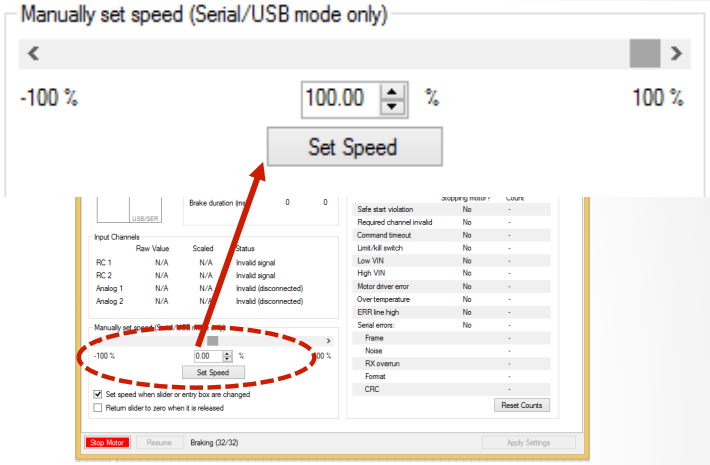
Motor

- Gear box reduction ratio is 26.9 : 1
- 1 revolution of the motor equals 753 counts of the encoder

Voltage supplier – supplies 12 volt.

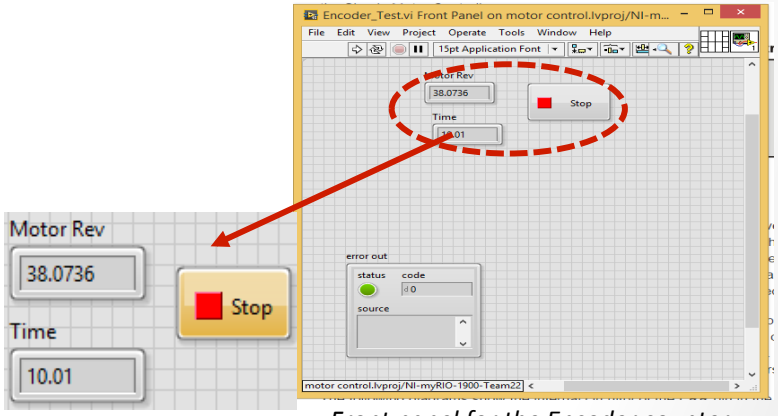
Speed Control Testing





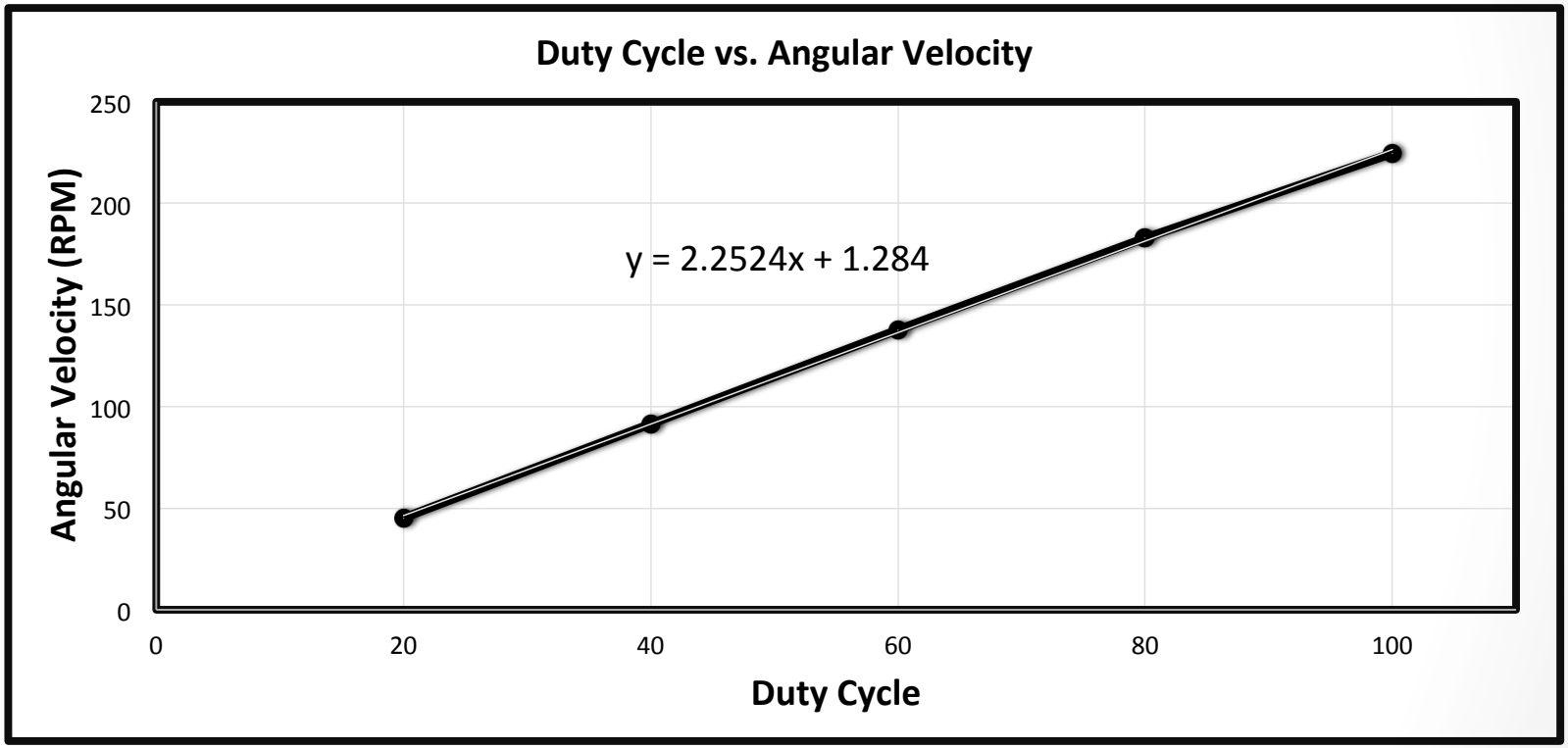
Pololu simple motor control (SPM) center

- **Use one of geared motor for the testing.**
- **Use Pololu SPM center to rotate the motor.**
- **Set speed is in range of –ve and +ve 100%.**

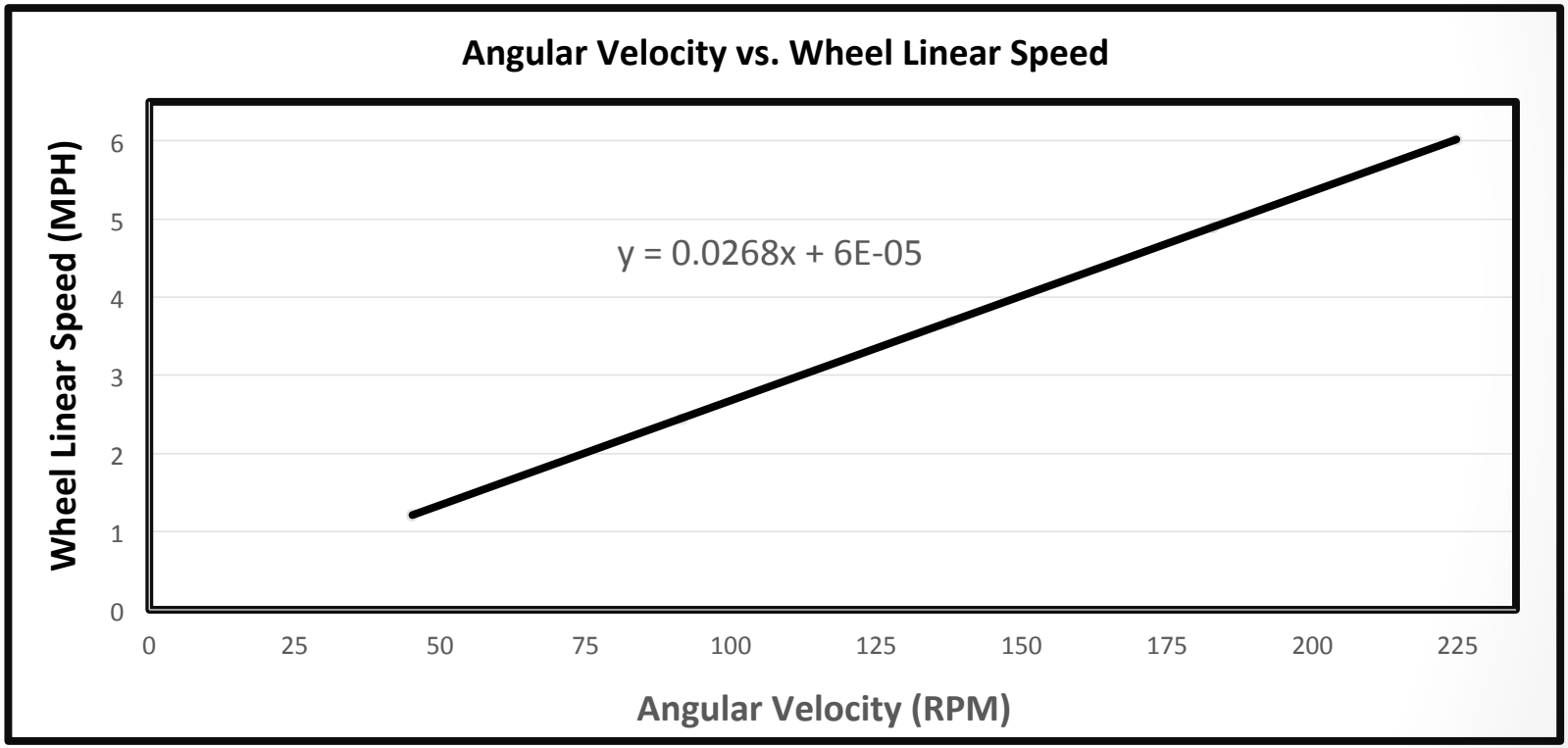


Front panel for the Encoder counter

Speed Control Analysis



Speed Control Analysis



Presenter:

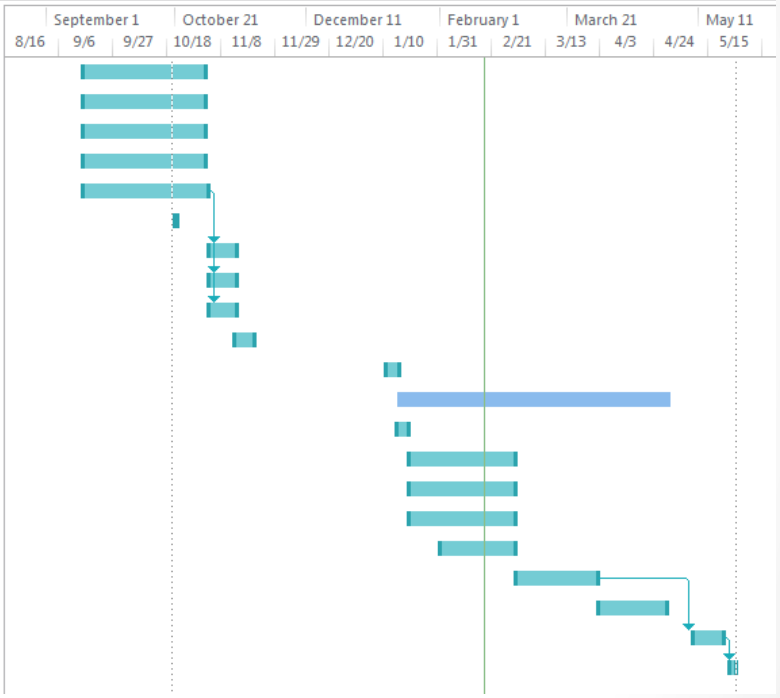
Budget Break Down

Part	Quantity	Unit Price	Total	Vendor
Polulu Simple High-Power Motor Controller 18v25 (1381)	3	54.95	164.85	Polulu
Mighty - Lite Caster Wheels (2835T31)	3	10.2	30.6	McMaster-Carr
Flat-Free Lightweight Polyurethane Wheel (22245T31)	3	47.64	142.92	McMaster-Carr
Raspberry Pi B+ (70377493)	2	30	60	Allied Electronics
PG27 Gearmotor w/ RS775 Motor & Encoder (am-2923)	3	85	255	AndyMark
Xbee 802.15.4 Modules	2	19	38	Digi
RPLidar 360	1	0	0	FAMU/FSU CoE
NI MyRio 1900	1	0	0	FAMU/FSU CoE
1" Al sq tubing 1/8" wall	1	164.64	164.64	McMaster-Carr
1/8 " aluminum Sheet	3	79.97	239.91	McMaster-Carr
Batteries	4	50	200	
Low-Carbon Steel Rod 1/2" Diam., 1' Length	1	3.09	3.09	McMaster-Carr
Low-Carbon Steel Rod 3/4" Diameter, 1' Length	1	6.94	6.94	McMaster-Carr
Low-Carbon Steel Rod 1-1/2" Diameter, 1' Length	1	22.61	22.61	McMaster-Carr

Total Budget	Spent	Remaining
3000	1295.92	1704.08

Gantt Chart

Task Mode	Task Name	Duration	Start	Finish
	Frame Design	35 days	Tue 9/15/15	Sun 11/1/15
	Motor Specifications	35 days	Tue 9/15/15	Sun 11/1/15
	Sensor Specification	35 days	Tue 9/15/15	Sun 11/1/15
	Processor Specifications	35 days	Tue 9/15/15	Sun 11/1/15
	Market Research	35 days	Tue 9/15/15	Mon 11/2/15
	Frame Material Selection	1 day	Wed 10/21/15	Wed 10/21/15
	Motor Selection	9 days	Tue 11/3/15	Fri 11/13/15
	Sensor Selection	9 days	Tue 11/3/15	Fri 11/13/15
	Processor Selection	9 days	Tue 11/3/15	Fri 11/13/15
	Finalize Design Plan	6 days	Fri 11/13/15	Fri 11/20/15
	Order Materials	5 days	Mon 1/11/16	Fri 1/15/16
	Prototype Completion	76 days	Fri 1/15/16	Fri 4/29/16
	Prototype Frame Machining	3 days	Fri 1/15/16	Tue 1/19/16
	Motor Mounting	29 days	Wed 1/20/16	Mon 2/29/16
	Speed Control	29 days	Wed 1/20/16	Mon 2/29/16
	Lidar Mounting	29 days	Wed 1/20/16	Mon 2/29/16
	Lidar Calibration	21 days	Mon 2/1/16	Mon 2/29/16
	Prototype Testing	24 days	Tue 3/1/16	Fri 4/1/16
	Image Processing Intergration	20 days	Sat 4/2/16	Thu 4/28/16
	Final Design Machining	10 days	Mon 5/9/16	Fri 5/20/16
	Test Final Design	3 days	Mon 5/23/16	Wed 5/25/16



Gantt Chart

	Prototype Completion	76 days	Fri 1/15/16	Fri 4/29/16
	Prototype Frame Machining	3 days	Fri 1/15/16	Tue 1/19/16
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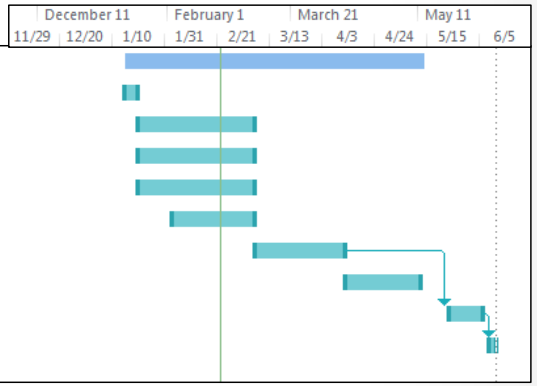


Conclusion/Future Plans

Conclusion

- Component ordering has been completed
- Wooden prototype fabrication
- Testing
  - Motor movement (forward/ reverse)
  - Obstacle Detection

Future Plans

- Resolve frequency issues between motor controller and MyRio
- Integrate speed control with 2 motors
- Prototype testing
  - Integrate vehicle movements with Lidar system
- Full electrical integration with prototype
- Bi-weekly conference calls with FIT
  - Collaborative updates

Reference

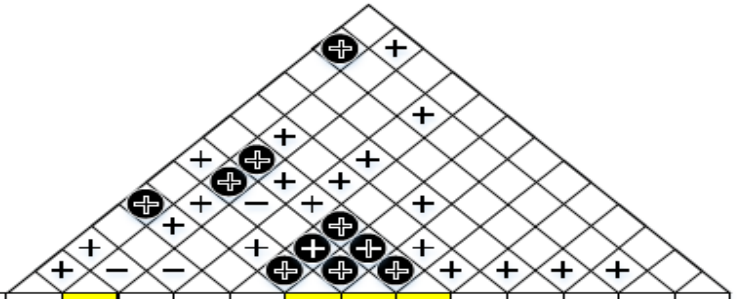
1. http://www.igvc.org/objective.html
2. http://www.igvc.org/2016IGVCRules.pdf
3. http://www.robotmarketplace.com/products/AME-210-1012.html
4. https://www.pololu.com/product/1381
5. https://www.sparkfun.com/products/13680

Questions?

Hous

Strong Positive	⊕
Positive	+
Negative	−
Strong Negative	⊖

Strong - 5
Medium – 3
Weak - 1



Design Requirements \ Engineering Characteristics	Design Requirement Weight	Cost	Sensors	Power	Motor	Image Analysis	Programming	Microcontrollers	Interfacing	Mobility	Differential Drive	Speed Control	Weight	Body Styling
Vehicle Speed	5	1	1	3	5	1	3	5	3	5	5	5	3	1
Size	1	3	1	1	1	1	1	1	1	3	3	3	5	5
Lane Following	5	5	5	3	1	5	3	5	3	3	1	1	1	3
Obstacle Avoidance	5	1	5	1	5	5	3	5	3	5	3	3	1	1
Waypoint Navigation	3	3	3	1	1	1	3	5	3	1	1	1	1	1
Mechanical E-Stop	5	1	1	1	1	1	3	3	3	1	1	3	1	5
Wireless E-Stop	5	1	5	1	1	1	3	3	3	1	1	3	1	1
Absolute Importance		57	95	49	69	69	85	121	85	81	61	81	43	63
Relative Importance		6	11	6	8	8	10	12	10	9	7	9	5	7
Rankings		6	2	7	5	5	3	1	3	4	6	4	8	6

Presenter:

Decision Matrices

Steering	Base	Control	Feasability	Speed	Total
Differential Steering	0	7	7	7	21
Skid Steering	0	7	5	5	17
Tank Tread	0	5	3	3	11
Steering Fans	0	3	3	5	11
Ackerman Steering	0	5	0	5	10

Body Structure	Base	Manufacturability	Weight	Availability	Total
Tubing Frame	0	7	5	7	19
Sheet Material	0	7	5	5	17
3D Printed	0	5	5	3	13
Hovercraft	0	3	7	5	15

Materials	Base	Machinability	Density	Availability	Total
4130 Steel	0	7	3	5	15
Aluminum 6061	0	7	5	7	19
ABS Plastic	0	5	7	5	17
Wood	0	5	7	5	17

Presenter:

Decision Matrices

Processor	Base	Power Consumption	Processor Speed	Memory	Total
NI MyRio 1900	0	5	5	5	15
Raspberry PI 2	0	5	7	7	19
Arduino	0	5	3	3	11
MSP430	0	5	3	3	11

Sensor	Base	Accuracy	Range	Speed	Total
Infrared	0	5	0	5	10
Ultrasonic	0	3	5	7	15
Radar	0	3	5	5	13
Lidar	0	7	7	7	21

Vision	Base	Resolution	Intigration	Accuracy	Total
Pixi Cam	0	7	7	5	19
USB Camcorder	0	5	3	5	13

Power	Base	Capacity	Voltage	Weight	Total
Lead Acid	0	7	5	5	17
Lithium Ion	0	7	7	7	21
Nickel-Metal Hybrids	0	7	5	5	17
Lithium Polymer	0	7	5	3	15

Presenter:

RPLidar Scan 1 Data

Sheet1

#RPLIDAR #COUNT=292	SCAN	DATA
Angle (Degrees)	Distance (mm)	Quality
0.4219	918.8	14
1.5	897	12
2.6406	863.5	14
5.0469	812.3	15
6.1719	794	15
7.2969	776	16
8.5156	764.5	14
9.6094	739.3	13
10.7969	719.5	17
11.9531	704.5	15
13.1719	687	15
14.3281	674	18
15.3906	660.8	17
16.7031	648.5	17
17.7813	639.3	23
18.7344	629.3	20
19.8594	616.3	21
21.2188	606.8	16
22.2031	622.5	24
23.2656	638.3	17
24.1563	659.8	14
25.3281	675.3	14
26.2813	698.3	9
27.2813	751.8	20
28.3906	742.3	19
29.5	737	19
30.6406	730	16
31.7969	720.8	19
32.9688	716	20
34.0156	709.3	19
35.25	702.8	22
36.25	696.8	22
37.5156	691	22
38.5781	686.8	21
39.7188	681	21
40.7656	677.8	22
42.0156	675.5	22
43.0781	668.5	21
44.2188	667.8	20
45.2344	663.8	21
46.4688	660.5	20
47.6406	659.5	22
48.625	657.5	22
49.8438	655.5	24
51	654.5	25
52.0469	651.8	24

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53.1875	652.8	26
54.25	651.3	26
55.4219	651	26
56.5313	650	30
57.625	652	41
58.6563	650	28
59.7656	650.5	26
61	651.8	28
62.0313	654.8	25
63.1875	655.5	24
64.2656	655.5	23
65.4375	656.5	23
66.625	657.5	22
67.7031	661.8	21
68.8594	661.8	19
69.8594	666	21
71.0469	672.3	23
72.1875	674.5	23
73.125	677	21
74.1875	682.5	20
75.3125	686.5	18
76.5156	690.8	23
77.5	697	21
78.6406	701.8	20
79.7813	707	17
80.8281	713.5	20
82.0625	719.5	21
83.125	725.8	19
84.125	734.3	19
85.3281	740.8	21
86.4531	748.5	19
87.4531	761	18
88.4844	772.8	17
89.7188	778.8	19
90.8125	789	20
91.9219	797	17
92.875	808.8	16
94.0938	821.3	19
95.1406	831.8	18
96.2188	846.3	19
97.25	858	16
98.4375	875.3	19
99.5	885.3	16
100.625	909	19
101.625	924.3	16
102.8125	945.5	16
103.8125	968.3	16
104.9219	980.5	15
106	1006.8	17

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RPLidar Scan 2 Data

Presenter: Allegra Nichols