Team 22: Autonomous Ground Vehicle

Midterm Presentation 2

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Sponsor: Florida Space Grant Consortium

Advisor: Dr. Nikhil Gupta

March 17, 2016

Overview

- Introduction
  - Intelligent Ground Vehicle Competition
  - Team Dynamics
- Previous Work
  - Prototype Construction
- Current Progress
  - Speed Control
  - Obstacle Avoidance Techniques
  - Emergency Stops
- Future Work
  - Image Processing

Intelligent Ground Vehicle Competition (IGVC)

- Annual design competition
  - June 3rd, 2016
- Competition Constraints
  - Time Limit
  - Speed Restrictions (1~5 mph)
  - Obstacle Avoidance
  - Lane Detection
- Design Constraints
  - Size
  - Power
  - Emergency Stops
  - Payload

Team Dynamics

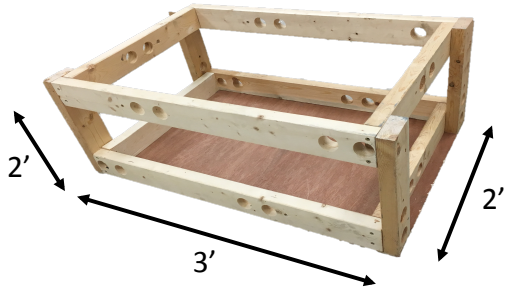
- Multidisciplinary Cross-Collaboration
- FAMU-FSU College of Engineering (COE)
- Junior FIT Team (Melbourne, FL)
  - 2 year project
- Working toward the common goal of qualifying and competing in IGVC
- Biggest challenge is communication

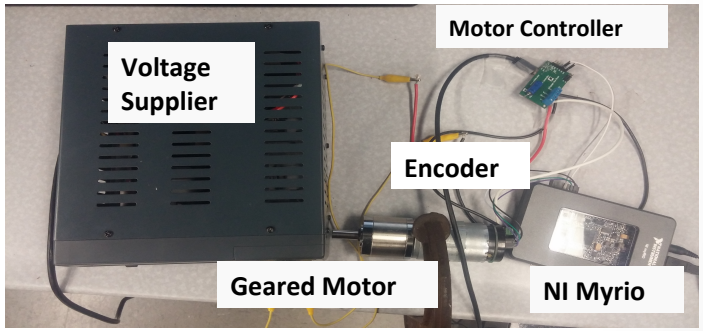
- FAMU/FSU
  - Structure Fabrication
  - Vehicle Speed Control
  - Emergency Stops
  - Battery Selection

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

Previous Work

- Frame Fabrication
  - Simple wooden frame
  - Eases maintenance
- Motor Mounting
  - Extended shaft addition to remove stress on motor output shaft
  - Bearing removal to attach the extended shaft firmly on the wheel
- Motor Familiarization
  - Open-loop speed control
  - Vary wheel speed at desired rate
- Lidar Obstacle Detection
  - 2D mapping
  - Obstacle location detection

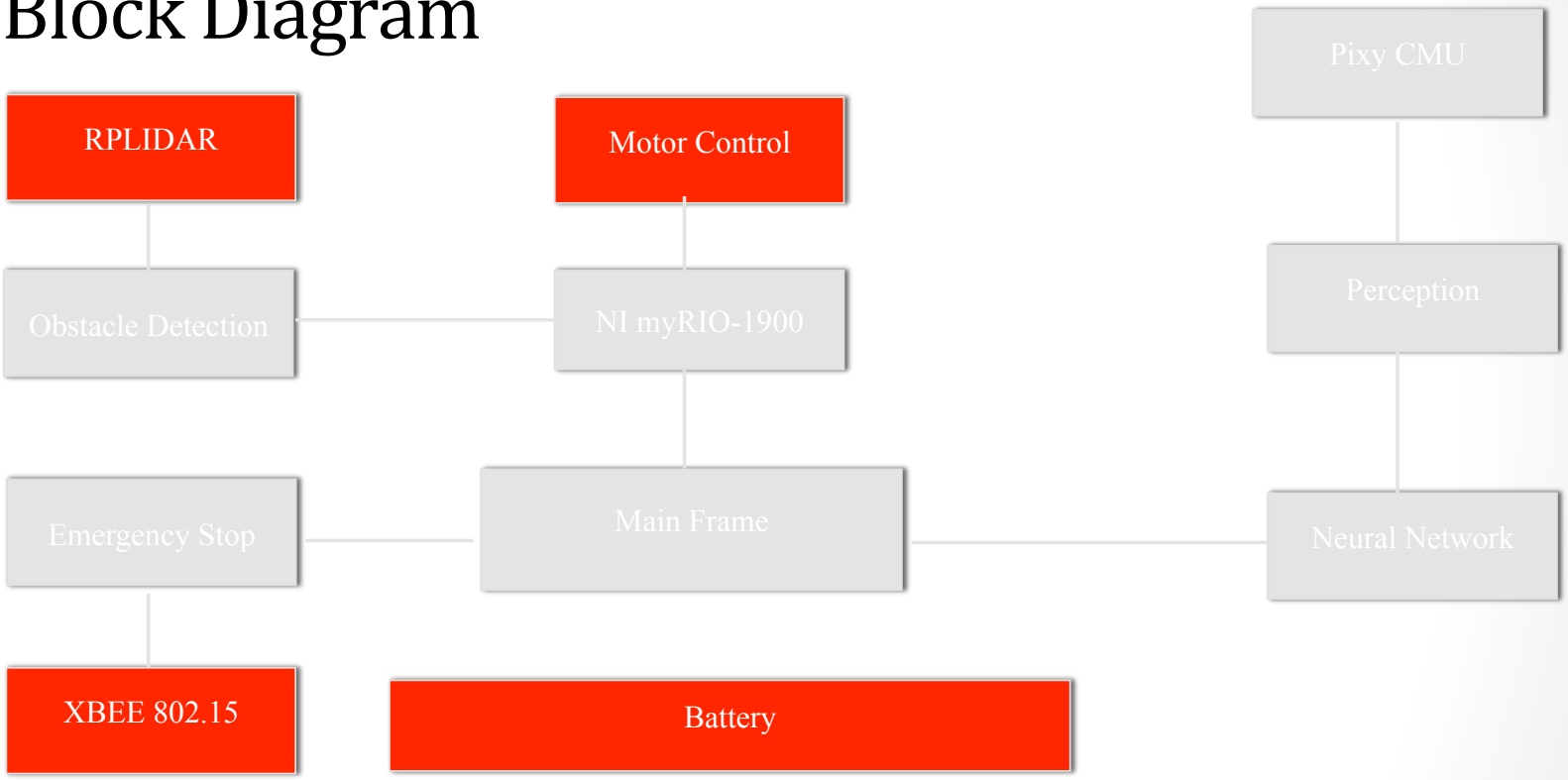




Current Progress

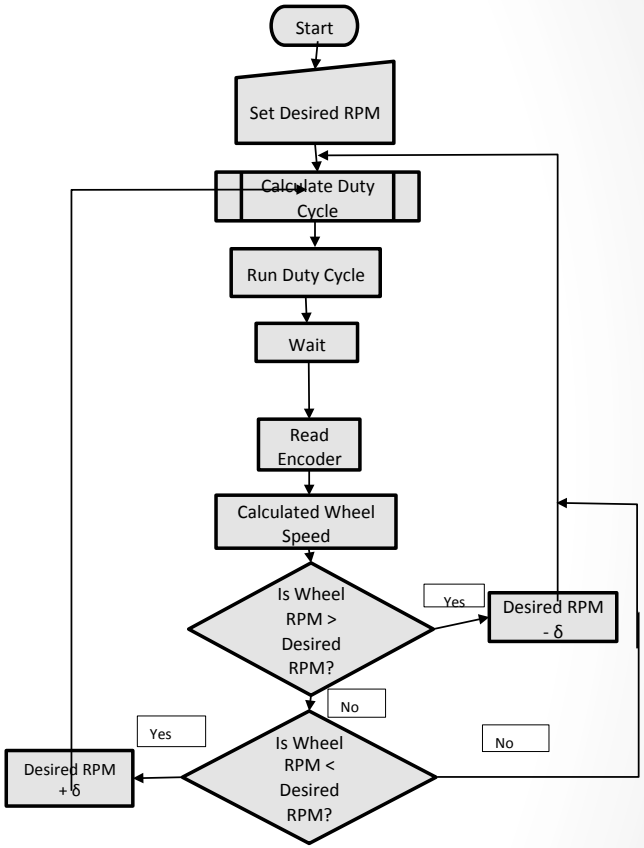
- Speed Control
  - Closed loop control
- Lidar Obstacle Detection
  - Localization and mapping
- Wireless Stop
  - XBee communication and integration with motor controllers
- Battery Selection

Block Diagram



Speed Control

- Input initial duty cycle
- Interpret encoder readings to obtain wheel velocity
- Adjust duty cycle based on the desired and actual wheel velocity



RPLIDAR – Localization and Mapping

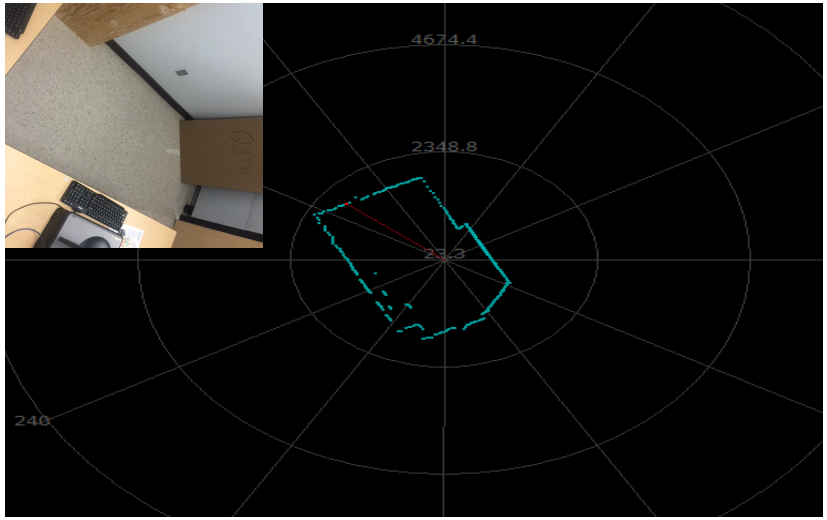
What does the surrounding environment look like?

- Mapping is a matter of integration the information gathered from the vehicle's sensors into a given representation
- Central aspects of mapping include the representation of the environment of the interpretation of the sensor data.

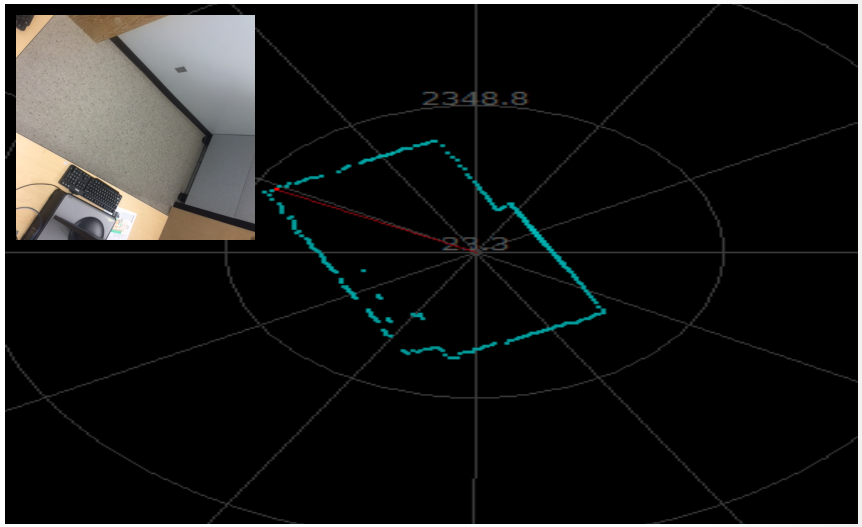
Where am I?

- Localization is a matter of estimation the position of the vehicle relative to a map.
  - GPS Waypoint Navigation

Mapping & Obstacle Detection



2D Mapping without Obstacle



2D Mapping with Obstacle

Battery

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

Table 1 - Voltage and Current Distribution

Component	Voltage (V)	Current (A)
RS775 Motor A	12 ~15	22*
RS775 Motor B	12 ~15	22*
Fan	7 ~12	~0.2
NI myRIO-1900	--	~0.8-2.3
Total		~45.70

*Note: Current at maximum torque load

Battery Selection

Thunder Power 7700-4SM70

7700mAh 4-Cell/4S 14.8V Magna Series 70C LIPo split w/ interconnect

Specifications:

- Max Charge 12C
- Max Charge Current 92.4A
- Max Continuous Discharge: 70C
- Max Continuous Current 539A
- Max Burst: 140C
- Max Burst Current 1078A
- Weight: 780 g
- Price $300

Thunder Power 7700-4SM70

Battery Selection

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  - Stored Charge of the battery decreased at a lower rate.
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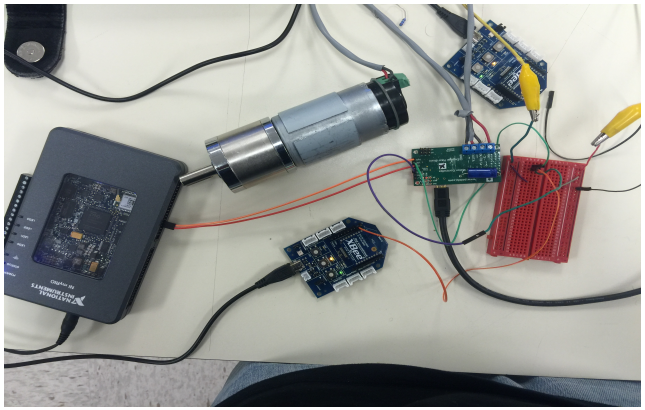
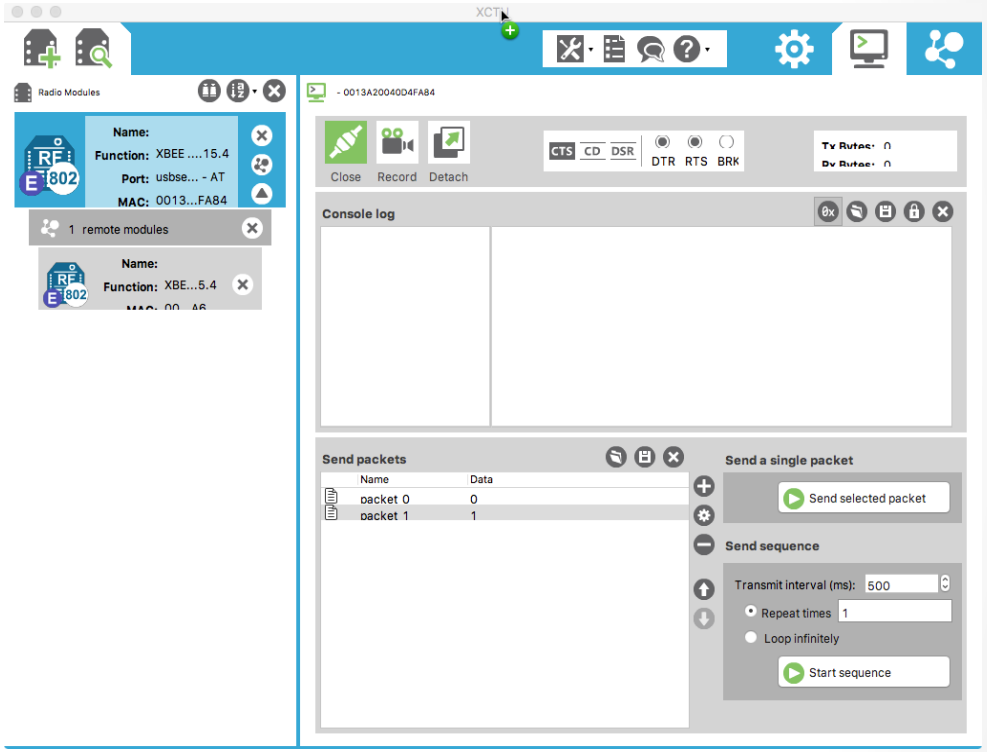
*Note: Current at maximum torque load

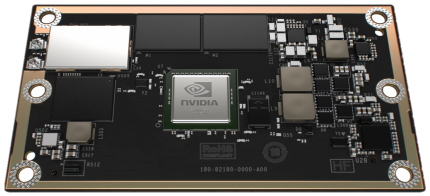
Emergency Stops



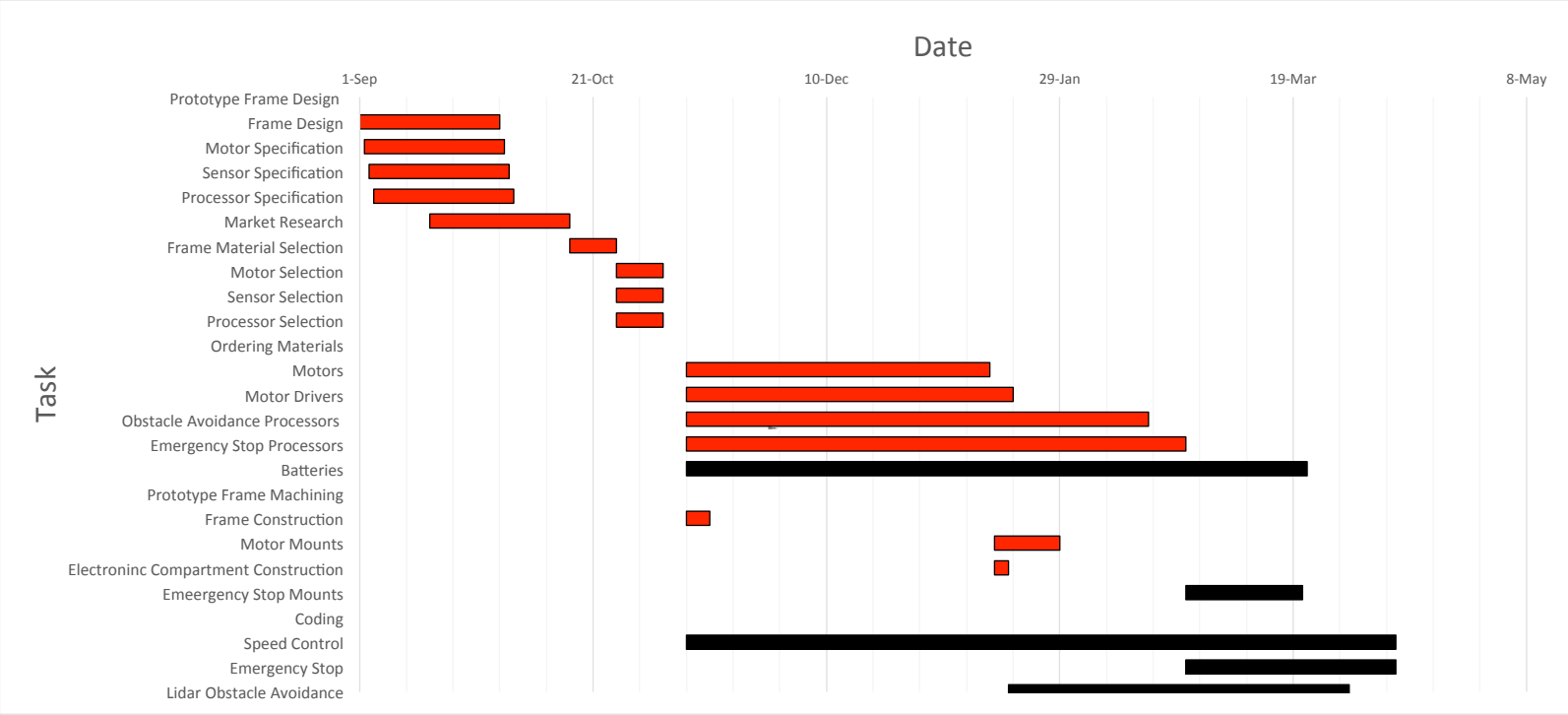


Florida Institute of Technology

- Sending prototype to FIT team members
- They will integrate image processing with speed control and Lidar system
- Image processing will detect obstacles as well as the guide lines for the course
  - They are implementing these techniques using:
    - Nvidia Jetson
    - Project Tango
    - Pixy Cameras



Future Work


Date
1-Sep
21-Oct
10-Dec
29-Jan
19-Mar
8-May
Task
Prototype Frame Design
Frame Design
Motor Specification
Sensor Specification
Processor Specification
Market Research
Frame Material Selection
Motor Selection
Sensor Selection
Processor Selection
Ordering Materials
Motors
Motor Drivers
Obstacle Avoidance Processors
Emergency Stop Processors
Batteries
Prototype Frame Machining
Frame Construction
Motor Mounts
Electroninc Compartment Construction
Emeergency Stop Mounts
Coding
Speed Control
Emergency Stop
Lidar Obstacle Avoidance

Future Work

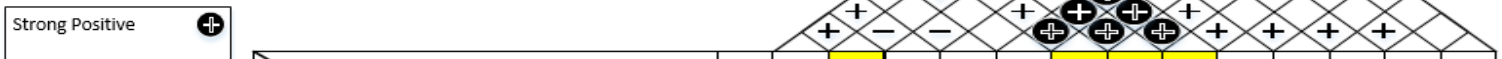

Date
15-Dec
4-Jan
24-Jan
13-Feb
4-Mar
24-Mar
13-Apr
3-May
Task
Ordering Materials
Motors
Motor Drivers
Obstacle Avoidance Processors
Emergency Stop Processors
Batteries
Prototype Frame Machining
Frame Construction
Motor Mounts
Electroninc Compartment Construction
Emeergency Stop Mounts
Coding
Speed Control
Emergency Stop
Lidar Obstacle Avoidance

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?

House



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

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

RPLidar Scan 1 Data

Sheet1

#RPLIDAR #COUNT=292 Angle (Degrees)	SCAN Distance (mm)	DATA 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

Page 1

Sheet1

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

Page 2

Sheet1

RPLidar Scan 2 Data

Sheet1

#RPLIDAR #COUNT=292	SCAN	DATA
Angle (Degrees)	Distance (mm)	Quality
0.0156	1103.5	12
1.1719	1071.3	15
2.375	1033.8	15
3.5781	993.8	15
6.0469	919.3	15
7.25	896.8	14
8.4688	859.3	14
9.7344	837	18
10.9688	807.8	16
12.1094	790.3	18
13.3438	772.8	14
14.625	746.8	17
15.75	727.8	13
17.0781	709.3	14
18.125	694.3	19
19.2969	703.5	24
20.4375	716.5	14
21.4063	738.3	15
22.5938	750	13
23.7188	776.5	15
24.75	830	19
25.8906	821.3	22
27.0625	802.3	17
28.375	794.8	20
29.5625	784.3	23
30.7344	777	22
31.8906	763.5	20
33.0938	755.3	20
34.1875	743.8	23
35.4844	735	21
36.5313	728.8	18
37.875	718.3	19
38.9688	712.5	21
40.1875	705.8	20
41.2344	699.8	22
42.5781	693	24
43.8125	690.3	24
45.0781	681.8	22
46.1719	678	24
47.3594	675	23
48.5781	670.8	23
49.6094	666.5	20
50.9688	664.3	23
51.9531	660.3	24
53.3281	658.3	23
54.4688	655.8	23

Page 1

Sheet1

55.5469	655.3	24
56.8438	653.3	27
57.9688	652	25
59.1406	652.3	28
60.2188	649.8	30
61.4844	650.3	31
62.6875	649.3	28
63.6719	650	26
65.0313	651	29
66.1406	651.3	28
67.375	650.8	26
68.4219	652.8	27
69.6094	654.5	26
70.875	655	26
72.0781	655.8	25
73.1406	658.5	24
74.3125	660.8	22
75.5469	665.5	22
76.6094	667	21
77.7813	669.3	23
79.0781	675.3	24
80.0625	680	23
81.3125	682.3	23
82.5156	688.5	23
83.625	692.8	22
84.7969	701.5	23
85.9063	705.5	19
87	713.3	22
88.2344	720.3	21
89.4375	725.8	20
90.5938	737.3	17
91.6563	742.5	22
92.8281	752.3	20
93.9688	763.3	20
95.0781	773	19
96.3281	783.3	23
97.4219	794	21
98.6094	805	19
99.7344	816	21
100.9688	828.3	18
102.0625	843.3	23
103.1875	853.8	16
104.375	869.5	17
105.4063	891	19
106.6563	909.8	18
107.7969	918.8	18
108.9063	945	17
109.9844	973	18
111.2031	983.3	16

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