
[1] Space Traveler

IEEE Southeast Con 2019 Team Presentation 2

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Southeast Con Team members

Chase Sapp	Captain
Chendong Yuan	Lead Control System Engineer/Financial Advisor
Fabio Trinidad	Lead Hardware Engineer
Kyle Voycheske	Lead Mechanical Engineer
Daniel Delgado	Lead Software Engineer

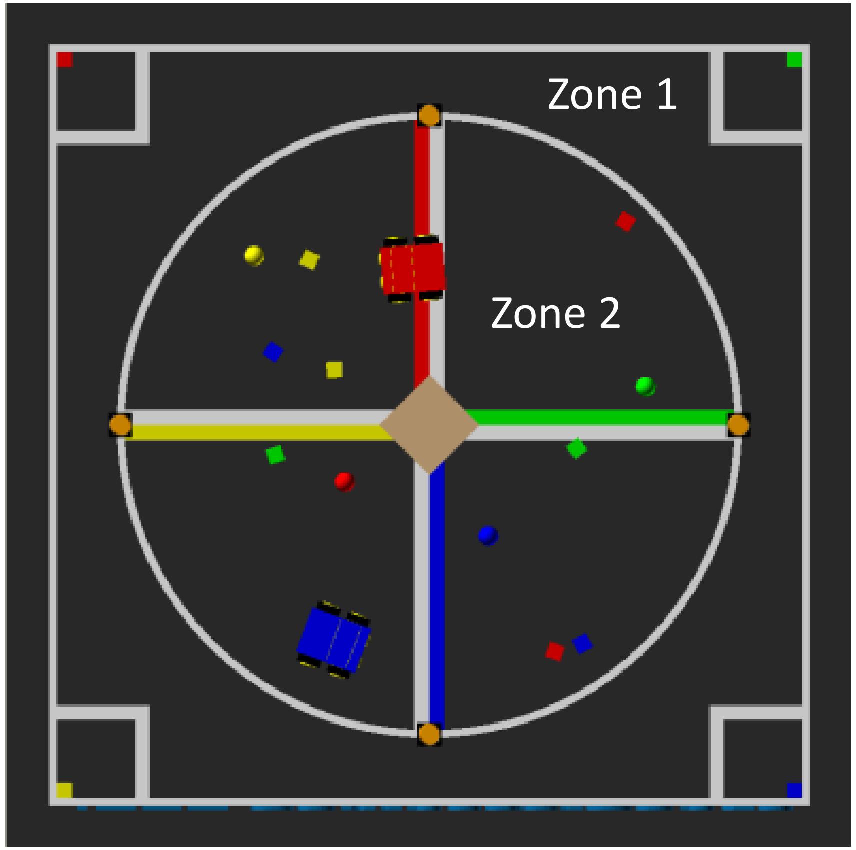
Update Since Last Presentation

- Targets
- Concept Generation
- Concept Selection
- Moving away from Version 0 to Version 1

How to Earn points in the competition

Southeast Con 2019 Hardware competition Point System [1]

Points	Task
5 pts	Leave home base and enter Zone 1
5 pts	Cross the orbital line into Zone 2 (first time only)
5 pts	For each complete, counter-clockwise orbit within Zone 2, starting from the quadrant closest to designated corner square
10 pts	Debris removed from Zone 2 (each)
10 pts	Debris placed in home base (additional to removal)
10 pts	Color-matched debris placed in appropriate color corner square (bonus points)
10 pts	Finish in your home base
25 pts	At conclusion of debris removal, raise your onboard flag while in home base
-10 pts	Every collision with a Spacetel



[1] Southeast Con 2019 Playing Field

Module Breakdown

Module	Lead of Module
Motion	Daniel Delgado
Route Clearing Algorithm	Kyle Voycheske
SortingSoftware and Hardware	Chase Sapp
Return Home	Chendong Yuan
Recognize and Avoid	Fabio Trinidad

Material Solution Selection

- Based on three specific criteria's:
  - Yield Strength
  - Light Density
  - Overall Cost
- Three different materials considered:
  - Hardwood Plywood
  - 6060 Aluminum
  - Fiberglass
- Settled on 6060 Aluminum due to its high yield strength, reasonable cost
- Downside to the aluminum was its high density

Battery Solution Selection

- Based on three specific criteria's:
  - Wattage
  - Size
  - Amp Hours

Power Consuming Components	Wheel Drive Motors	Gathering Motor	Storage Rotating Motor	Elevator Motor	Pixy 2	Ardunio Mega
Voltage	12V	12V	12V	12V	5V	5V
Current	350mA	350mA	330mA	330mA	140mA	200mA
Watts	4.2W	4.2W	3.96W	3.96W	0.7W	1W

- Three different batteries considered:
  - HitLights
  - Talent Cell
  - Duracell Ultra

Decided to go with the Talentcell battery due to its compact size and ample amount of amp hours.
One downside to the battery was its average amount of wattage.

Daniel Delgado

Motor Solution Selection

- Based on three specific criteria's:
  - RPM (Revolutions per minute)
  - Operating Voltage
  - Size
- Three different motors considered:
  - SparkFun Motor
  - CE gear Brushless Motor
  - 8V DC High Speed Motor
- After careful consideration, decided the CE gear Brushless Motor was optimal due to its high RPM and desired operating voltage.
- One tradeoff of the motor was its average size.

Movement Module Selection Summary

- Priorities in movement:
  - Strong, cost-effective, and lightweight frame material
  - Batteries with ample amp hours, compact size, and reliable wattage
  - Motors with high RPM (5000 RPM), within desired operating voltage, and compact size
- Final Selections:
  - 6060 Aluminum for frame material due its high yield strength and reasonable cost
  - Talentcell battery due to its ample amp hours and compact size
  - CE gear Brushless Motor for its high RPM and desired operating voltage

Route Clearing Algorithm Concepts

1. Predetermined Route:
   - Navigate along a predetermined route
2. Debris to Debris:
   - Navigate from debris to debris
3. Predetermined Route with Debris Searching:
   - Navigate along a predetermined route while actively searching for debris
4. Survey and Route Plan:
   - Navigate by surveying the field, identifying the debris, and planning an optimal route to collect the debris

Route Clearing Algorithm Selection

Predetermined route with debris searching

- Good at:
    - Finding debris
    - Avoiding known objects
- Average at:
    - Resisting environmental noise
    - Time to avoid UFOs

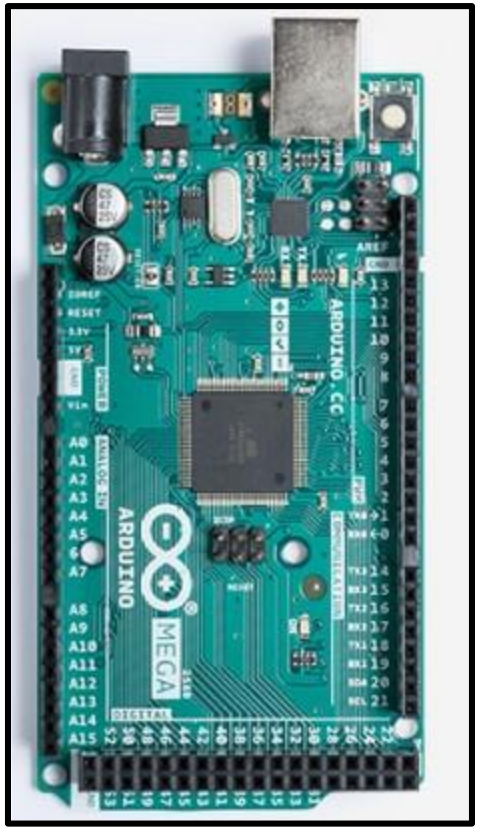
Selection of Criteria	Concepts			
	Predetermined Route	Debris to Debris	Predetermined Route with Debris Searching	Survey and Route Planning
Searching the Playing Field	-	0	+	+
Known Object Avoidance	+	-	+	+
Resistance to Environmental Noise	+	-	0	-
Time to Implement UFO Avoidance Code	-	+	0	-
Score	-2	-3	9	3

Microcontrollers

1. Raspberry Pi B+
    - Up to 1 GB of memory
    - 1.4 GHz of processing power
2. Teensy 3.6
    - Smallest of the boards
    - 180 MHz of processing power
3. Arduino Mega 2560
    - The largest amount of available pins
    - 16 MHz of processing power
4. BeagleBone Blue
    - Designed specifically for robots
    - 1 GHz of processing power

Microcontroller Selection

- The Arduino Mega
  - Trade offs
    - Has a low processing power (16 MHz)
    - Small amount of available memory (256 KB)
    - Slightly larger than the Raspberry Pi and BeagleBone
  - Advantages
    - More pins (54) than the Raspberry Pi (40) and BeagleBone (42)
    - Requires little power to operate
    - Proficient at managing time sensitive operations
    - Specifically designed to interface with sensors



[2] Selected Microprocessor

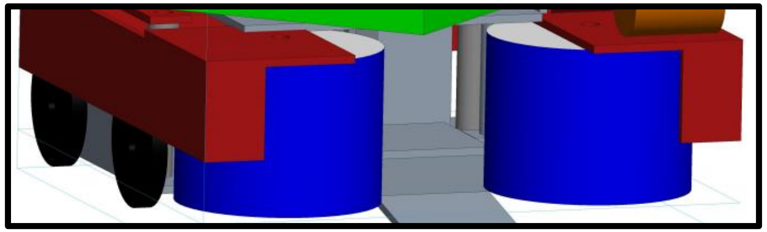
Gathering Solution

Gathering Methods	Max possible points	Power consumption	Gathering Time	Motor Count
Don't Gather Space Debris	1305	72W – 200W	0s	2
Extendable Arm System	360	60W – 150W	5s - 10s	3
Dual Brush System	360	36W – 100W	1s – 3s	1

	Weight	Baseline	Optimal	Description
Max Possible Points	5	210	360	Enough points to be competitive
Power Consumption	2	100W	60W	Amount of power the solution consumes
Gathering Time	4	5s	2s	Time to gather 1 piece of Space Debris

Selection of Criteria	Concepts: Don't Gather Space Debris	Extendable Arm System	Dual Brush System
Max Possible Points	+	+	+
Power Consumption	-	0	+
Gathering time	+	-	+
Score	7	1	11

SELECTION
Dual Brush System



[3] Brush Idea

Sorting Solution

[Type]	Sorting Time	Working Volume (L X W XH)	Motors	Recommended Storage Solution	Steps
Elevator meets Rubik's cube approach	5s – 20s	2.5" X 2.5" 2.5"	2	Rigid	5
Lane Driver	5s – 15s	5" X 5" X 5"	3	Rigid	4
Linear Memory	1s -5s	2.5" X 2.5" 2.5"	1	Linear	2

	Weight	Baseline	Optimal	Description
Sorting Time	5	5s	2s	The time to take to sort the space debris
Working Volume	3	2 pieces of space debris	1 pieces of space debris	The space available prior sorted needed
Motors	2	2	1	Amount of motors needed to sort

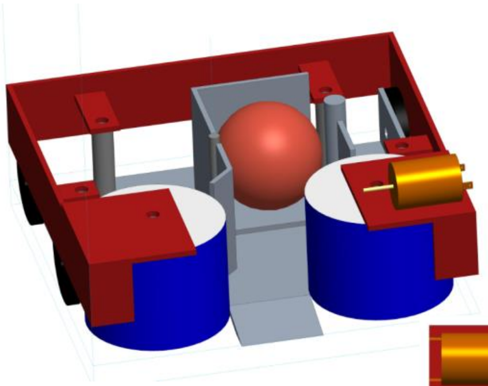
Selection of Criteria	Concepts		
	Elevator meets Rubik's cube approach	Lane Driver	Linear Memory
Sorting Time	-	-	+
Working Volume	+	0	+
Motors	0	-	+
Score	-2	-7	10

SELECTION
Elevator meets Rubik's cube approach

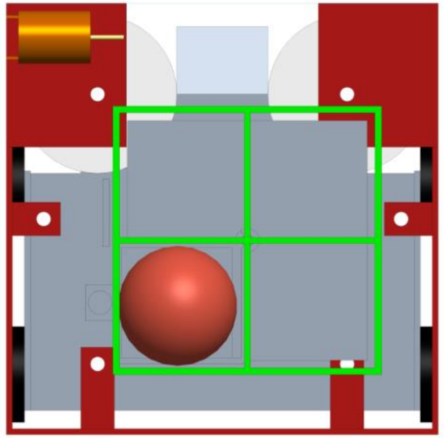
- Score wise Linear Memory is a better choice.
- Linear Memory requires robot to run from side to side when depositing space debris

Sorting Hardware Method

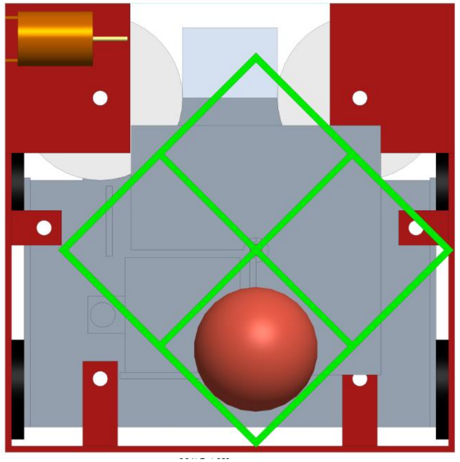
Step 1



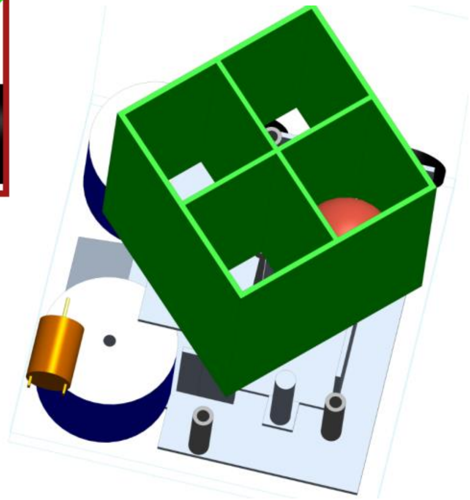
Step 2



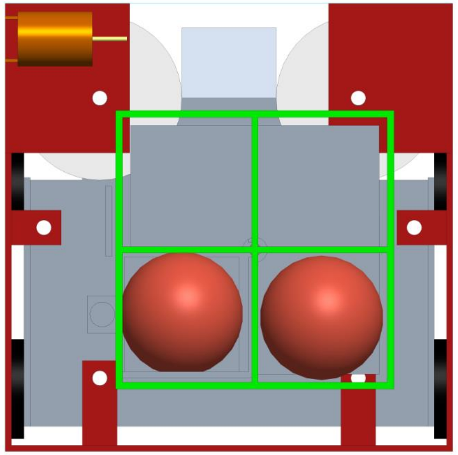
Step 3



Step 4



Step 5



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Storage Solution

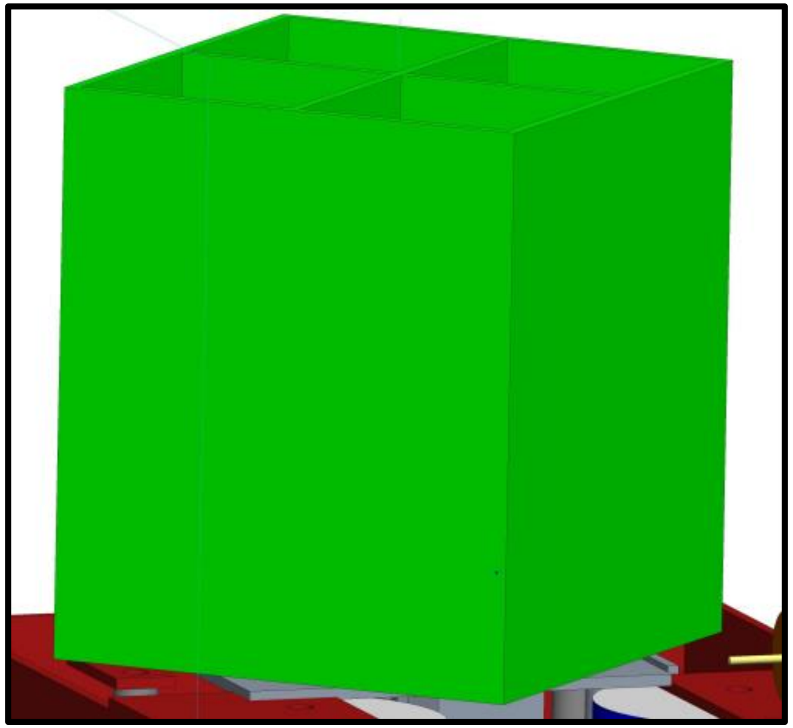
[Type]	Volume (L X W X H)	Amount of Space Debris	Keeps the Space Debris Sorted
Boxed Storage System	5” X 5” X 6.5”	12	Yes
Simple Sack Storage	5” X 5” X 6.5”	12	No
Horizontal Lane Storage System	6.5” X 7.5” X 2.5”	9	Yes

	Weight	Baseline	Optimal	Description
Volume (L X W X H)	3	5” X 5” X 6.5”	5” X 5” X 5.25”	Internal volume that the storage unit should hold
Keeps the Space Debris Sorted	5	Yes	---	Keeps the space debris sorted

Selection of Criteria	Concepts		
	Boxed Storage System	Simple Sack Storage	Horizontal Lane Storage System
Volume (L X W X H)	+	+	-
Keeps the Space Debris Sorted	0	-	0
Score	3	-2	-3

SELECTION

Boxed Storage System



Localization Concepts

1. Localize by IR sensor

- Measure the distance to the wall

2. Localize by pixy2

- By detecting the colored LED spacetels

3. Inertial navigation system

- Based on a gyro and accelerometer

4. Locate and go

- Locate by pixy2 and adjust the position by IR sensor

Localization Selection

Locate and go

Advantages:

- Less sensor
- Easy to implement

Worries:

- Additional IR sensor
- Flashlight and other lights

method	Time estimate	Accuracy	Ease of implementation	Possibility of error	Size of sens required
Distance from walls	30 seconds	moderate	moderate	moderate	low
Color of spacetel	20 seconds	low	easy	high	none
With a gyro and code disk	15 seconds	high	very difficult	moderate	high
Locate and go	40 seconds	moderate	difficult	low	low
		-----		---	-

Wheels concepts

1. Airless wheel

- Solid inside
- High load
- Low friction

2. Medium-pressure wheel

- Medium pressure inner tube
- Medium load
- Enough friction

3. High-pressure wheel

- High pressure inner tube
- High load
- Low friction

4. Mecanum wheel

- A series of rollers attached to its circumstance
- Move to any direction

Wheels selection

- Medium-pressure wheels

Advantages:

- Easy to get
- Enough load
- Enough friction

Type	Price	Friction value	Reliability	Ease of programming	Load
Airless wheel	low	0.2	medium	easy	high
High pressure wheel	low	0.3	medium	easy	high
	-				
Medium pressure wheel	low	0.6	medium	easy	medium
Mecanum wheel	high	0.5	low	difficult	medium

Recognition & Avoidance Concept

1. Predetermined Object Size:
   - Use preprogramed algorithm for determining dimensions of object on field

2. Stopping and Scan Surrounding:
   - Robot remains static when it surveys its surrounding
   - Avoid collision with undetected objects

3. Surveying Field While Moving:
   - Will rely on predetermined object sizes and quick responding sensors will be need
   - A higher risk collision, due to possible sensor failure
   - Use a surveying algorithm at initial start of run to allow for more accurate reading

Recognition & Avoidance Concept

Surveying Field While Moving:

- Advantage:
  - Fast run time
  - Avoiding objects bigger than predetermined size
- Disadvantage:
  - Higher collision risk if sensor fails
  - Time to avoid UFOs is shorter

Method	Time Estimation	Complexity	Avoidance Percentage	Ease of Implementation	Possibility of Collisions
Predetermined Object Size	3 - 4 minutes	Simple - Moderate	80 – 90 %	Moderate	Low - Moderate
Stop and Scan Surround	4 - 6 minutes	Simple	95 - 99 %	Easy	Low
Surveying Field While Moving	2-3 minutes	Moderate	70 – 80 %	Moderate - Difficult	moderate

Sensors

1. Pixy2 CMUcam5 Sensor
   - Dedicated processor for image processing
   - uses color-based filtering algorithm (*Color Connected Components)*
   - CCC algorithm allows for remembering up to 7 different color signatures
   - Pixy2 calculates the color (hue) and saturation of each RGB pixel
   - 60 fps frame rate

2. TTL Serial JPEG Camera with NTSC Video
   - 30 fps frame rate
   - outputs NTSC video
   - take snapshots of the video (in color) captured
   - transmit snapshots over the TTL serial link

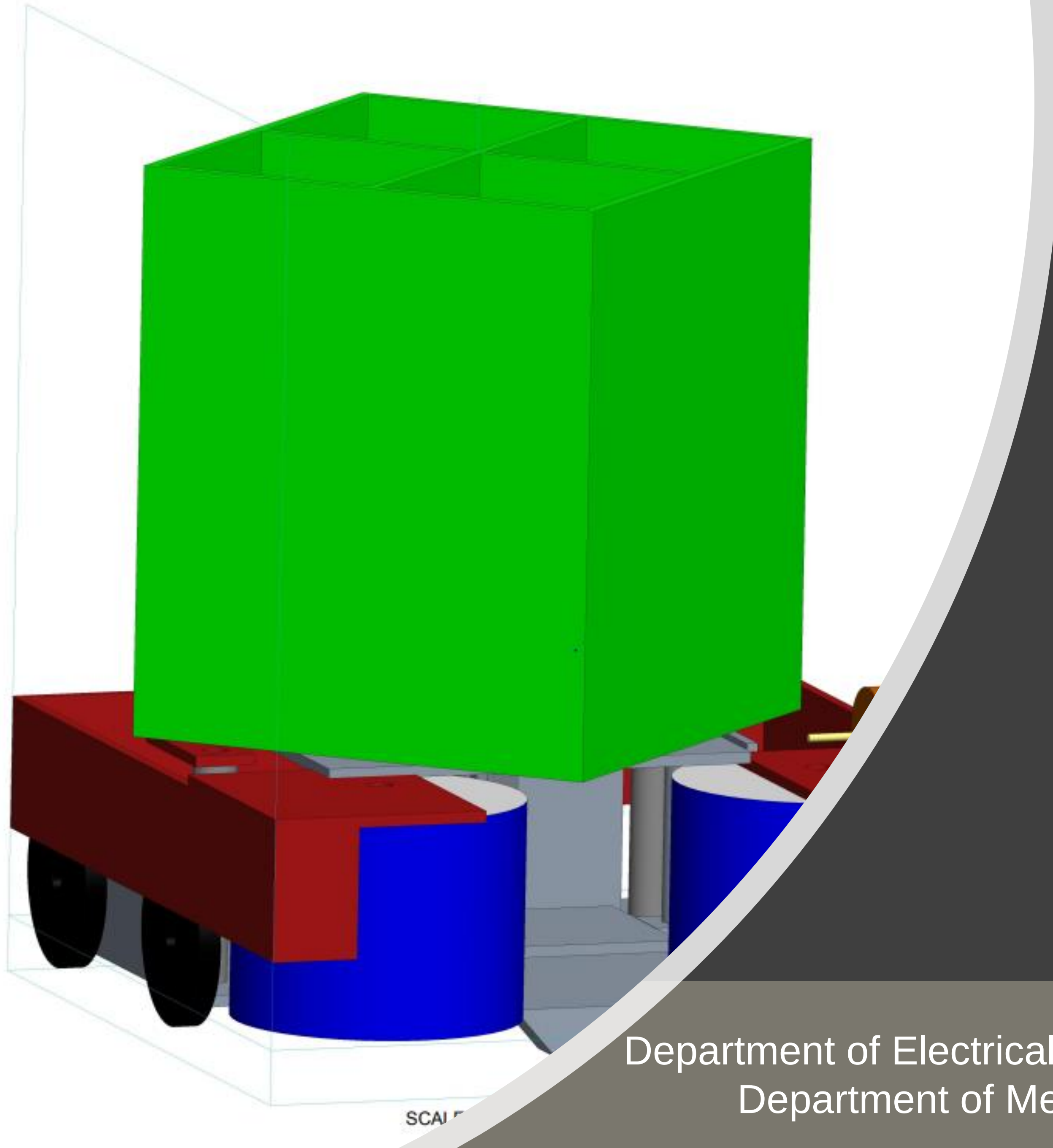
1. IR Distance Sensor (20cm-150cm Range)
   - Short distance
   - Detect object right in the line of sight of robot

2. IR Distance Sensor (100cm-500cm Range)
   - Long distance
   - Twice the detection range than previous IR sensor mentioned
   - Detects object straight ahead of robot

Sensor Selection

1. Pixy2 CMUcam5 Sensor
   - Trade offs
     - 60 degree horizontal and 40 degree vertical
     - Operating voltage slightly higher
   - Advantages
     - 60 fps frame rate
     - Built-in light for darker areas
     - Object detection greater than 80 cm
     - Specifically designed to interface with microcontroller

1. IR Distance Sensor (20cm-150cm Range)
   - Trade offs
     - Shorter detection range than other IR sensor
   - Advantages
   - Object detection greater than 80 cm



Overall Design

Question?

Reference

[1] *IEEE Future Directions*, sites.ieee.org/southeastcon2019/program/student-program/

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[3] Charly, and Housekeeper. “Quickie European Toilet Bowl Brush- 3041ZQK.” *The Home Depot*, The Home Depot, 26 June 2018, www.homedepot.com/p/Quickie-European- Toilet-Bowl-Brush- 3041ZQK/202260863.