ENGR 4590 Testing and Statistical Analysis Worksheet

Team Name: Grass Gone Roomba

This worksheet describes the quantitative and qualitative testing and analysis for an autonomous and remote-controlled lawnmower.

Table listing design constraints and test for each:

Constraint/Feature	Test/Performance Metric	Result	Explanation
Cut lawn within battery lifetime	Use lawnmower to cut a patch of grass and see if lawnmower will cut grass in time before running out of battery	Varying Results (Theoretically yes)	Depending on user or variable cut pattern patch of grass could be cut before battery died
Must be light enough for each team member to carry by themselves	Have every team member attempt to pick up and carry the lawnmower by themselves	Pass	Every team member was able to easily pick up the lawnmower
Must fit within .7 x .7 x.7 m	Measure outer dimensions which are .7 x .33 x .58 m	Pass	Measurements fit within dimensions
Must have adjustable cut length	Use mechanism to adjust cut length from 0 to 1.2 inches taller and test	Pass	Was able to adjust the cutting length using the mechanism
Must weigh less than 50 Kg	Weigh the lawnmower	Pass	Measurements fit within wight requirements
Lawnmower can detect and avoid obstacles	Turn on lawnmower to automatic cutting mode and see if lawnmower can detect and avoid obstacles	Close	Lawnmower can detect some obstacles but sometimes hits them while

			avoiding them or by going too fast
Emergency Stop button stops and turns off everything in lawnmower	Turn on lawnmower and as acting normally press Emergency stop button to see if	Pass	Whenever the emergency stop button is pressed everything on the mower turns off and it is not usable until the emergency stop button is released.
Camera can connect to phone for remote cutting	Use app and camera to turn on camera	Pass	Whenever the camera is turned on and the connections are made through the app in the phone, we were able to display the view on the phone.
Lawnmower can be controlled manually	The lawnmower can be controlled manually using the remote controller.	Pass	After making all the right connections, the user was able to control the lawnmower manually.

Qualitative evaluation: The project meets the design constraints and specifications. The system fits within the size and weight restrictions and can be transported by a single team member. It had a volume of 7 x .33 x .58 m and could fit through a standard doorway. The project includes a remote user interface with driving control (front, back, left, right), and camera control. Battery life is not quite as long as desired, but the battery is easily accessible for replacement and multiple batteries can be purchased from Amazon or Walmart.

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Quantitative testing: The testing consists of measuring the time the mower cuts a specific area of the grass, and timing the battery's life for the blade only, Mower drive only, and blade and mower drive together. Also, measuring the distance for the camera until the connections between the camera and the phone gets disconnected. As well as, testing for sensor distance consistency. Several photos of the solution processes are shown below.

Figure 1: Testing the speed of the Lawnmower

https://www.youtube.com/shorts/Anr09IbuvEw

Figure 2: Short video for testing the lawnmower ability to run on extreme elevation changes and slopes.

Test	Result (Time)
1	7.4s
2	7.5s
3	6.8s
4	7.2s
5	7s
6	7.3s
7	7.5s
8	6.9s
9	7.2s
10	7.4s
Average	**7.2s**
Standard Deviation	**0.6s**

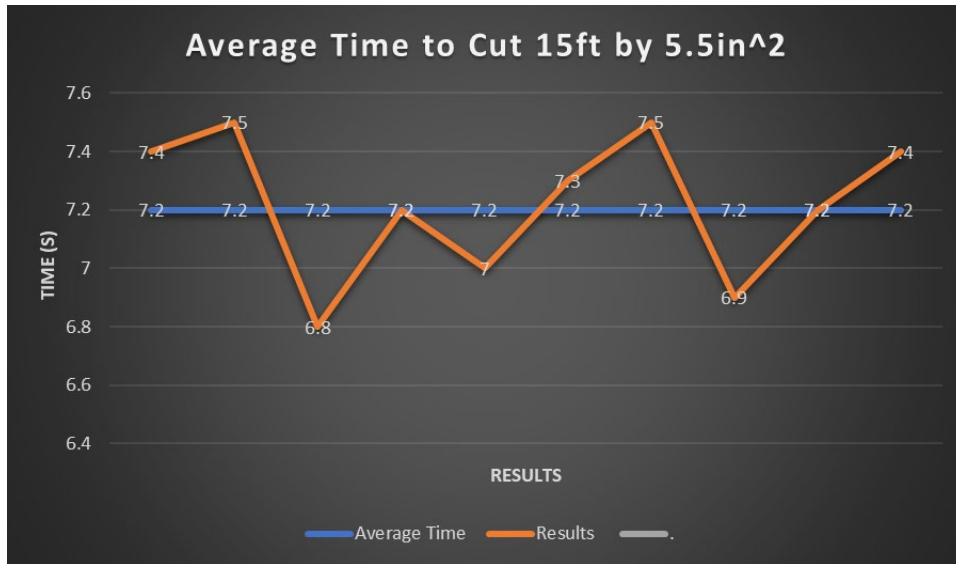**Figure 3:** Time it took to cut 15 ft by $5.5\ in^2$

Figure 4: Graph for the table in figure 3.

Battery Life Testing:

When it came to testing how long a run time we could obtain for our mower. We used the following tests to collect data to determine the life of the battery.

- Blade on only.
- Mower driving only NO blade on.
- Mower driving AND Blade on.

Here are the results:

Test: Blade Only	Results (Time)
1	15:06
2	14:30
3	16:12
4	15:30
5	16:39
Average:	**15:43**
Standard Deviation	**2:09**

Figure 5: Table for blade only run time for to still be able to cut grass

Test: Mower Drive Only	Results (Time)

1	18:17
2	19:20
3	20:03
4	18:45
5	19:51
Average:	**19:07**
Standard Deviation	**1:46**

Figure 6: Table for Mower drive only battery length running on grass

Test: Mower Drive and Blade run time	Results (Time)
1	9:46
2	9:21
3	9:09
4	9:56
5	9:34
Average:	**9.33**
Standard Deviation	**0.47**

Figure 7: Table for blade and mower run time for to still be able to move effectively

Camera Distance Testing:

When it came to testing the distance the lawnmower and the phone can be we set the lawnmower down in a specific location monitoring the picture the phone gave and walked slowly away from the lawnmower. We noticed after about 70 yards away the phone gave delayed response to what was being shown and fully stopped showing the correct picture after 100 yards away. We checked our positions roughly using google maps.
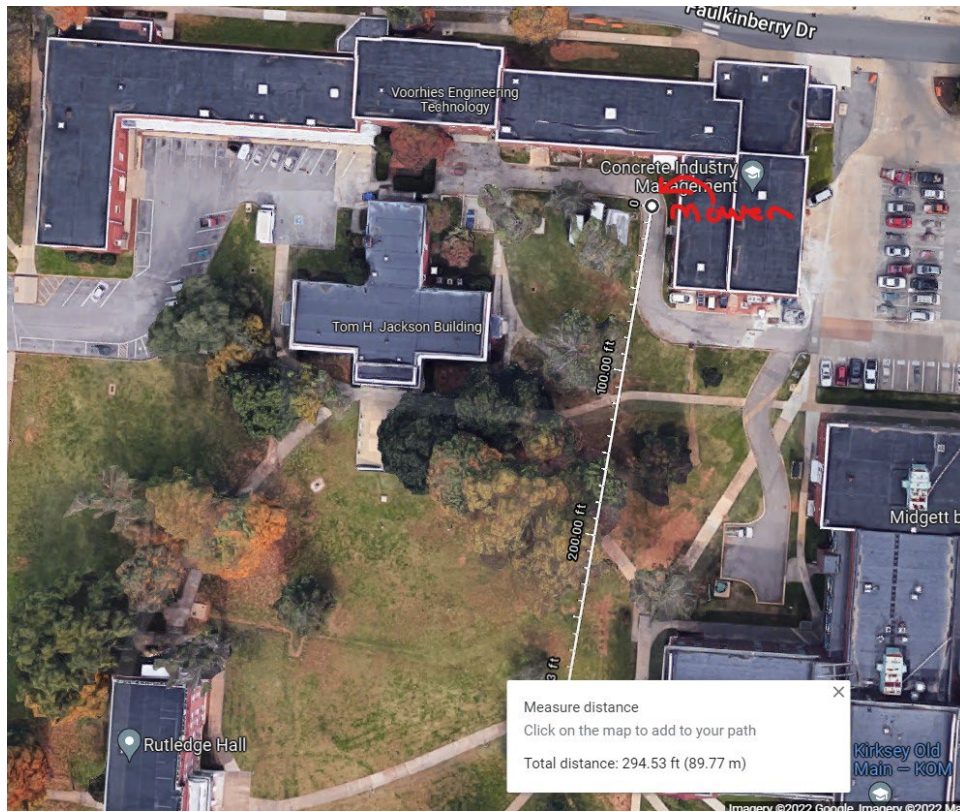
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Figure 8: Distance Measured Using Google Maps.

Sensor Distance Testing:

When it came to testing the sensors distance, we had one teammate pick up the lawnmower, used a tape measure for distance and moved our hand slowly for the ultrasonic sensor's detection. Our code stops our lawnmower once the sensor detects something within 20 centimeters. We evaluated from our testing that our sensors maintain a consistent reading of 20 centimeters.
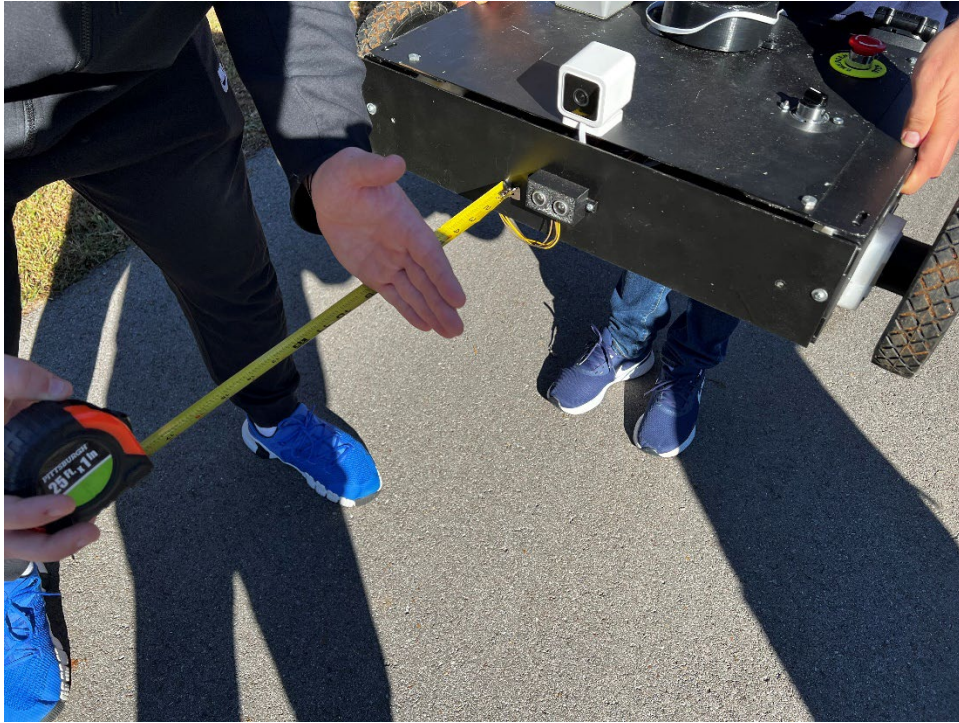
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Figure 9: Conducting Sensors Test Using Hand and Tape Measure