Snow Plowing Robot Progress Report

Carleton University
Department of Electrical and Computer Engineering

SYSC 4805

Group 7 (Lizard Green), Section L1

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Table of Contents

Team Name

The color that will represent group seven is “lizard green #A7F432”. This color was picked from the compact list of colors Wikipedia page given in the project outline.

Objective

The overall objective is to successfully design a snow plowing robot capable of clearing the snow off an area delineated by a closed black path.

Deliverables

This project aims to produce a design of an automated snow plowing robot. The designed robot should be capable of clearing the maximum possible snow within an enclosed black border. The robot will have a design capable of detecting and dealing with movable and non–movable obstacles. The robot must be able to clear all of the snow off of the area within a specific time constraint. The robot will be programmed to maximize snow clearance despite the obstacles present in the enclosed area. The design of the robot will also include a unique plow designed for the robot. During the design and testing process, the different sensors that will be used to achieve the design requirements by object detection and mapping will be of the same type and specifications as the ones commercially available and a budget list of actual sensors required to implement the robot will also be created.

Scope

Functional Requirements:

- The robot's main functionality will be to clear off snow from a 12m x 12m square area. A rounded square black path encloses this area.
- When the robot starts in its idle state at the parking spot the maximum width, length, and height is 0.5m x 0.8m x 1m respectively.
- After the simulation starts the robot's moving parts may not exceed a width, length, and height of 1m x 0.8m x 1m respectively.
- Any sensors that are added to the robot must reflect a real-world sensor. Each sensor is required to have a similar sensor in an online distributor of electronic components. An example of these distributors are DigiKey, Mouser, etc. A link to the real-life sensor from these distributors will be attached to the progress report.
- The robot has a maximum speed of 2 m/s. The target velocity of the motors will be measured in radian deg/sec based on how large the wheel size is. This will be done through the dynamic properties of the motors. The maximum amount of torque will also be decided.
- The snowplow must plow all the snow in under 5 minutes. If the simulation lasts longer than this it will be concluded that the snowplow was not successful.
- Python will be the selected language. Python is suitable for this project because it is a robust and relevant language allowing for the rapid development and testing of plow bots.
- CoppeliaSim will be the software that is used to simulate the snow clearing robot.

Non-Functional Requirements:

- The robot should be reliable and repeatedly completely plow all the simulated snow without unexpected failures.
- The robot should have good performance. For example, the robot shouldn't spend much time plowing an already plowed area which wastes energy and time.
- The robot should use as small an amount of material as possible allowing for a more environmentally-friendly build. This would also include using the minimum amount of sensors needed to successfully plow all of the snow. This would also cause the robot to be cheaper to manufacture in a real-life scenario.

Work Breakdown Structure

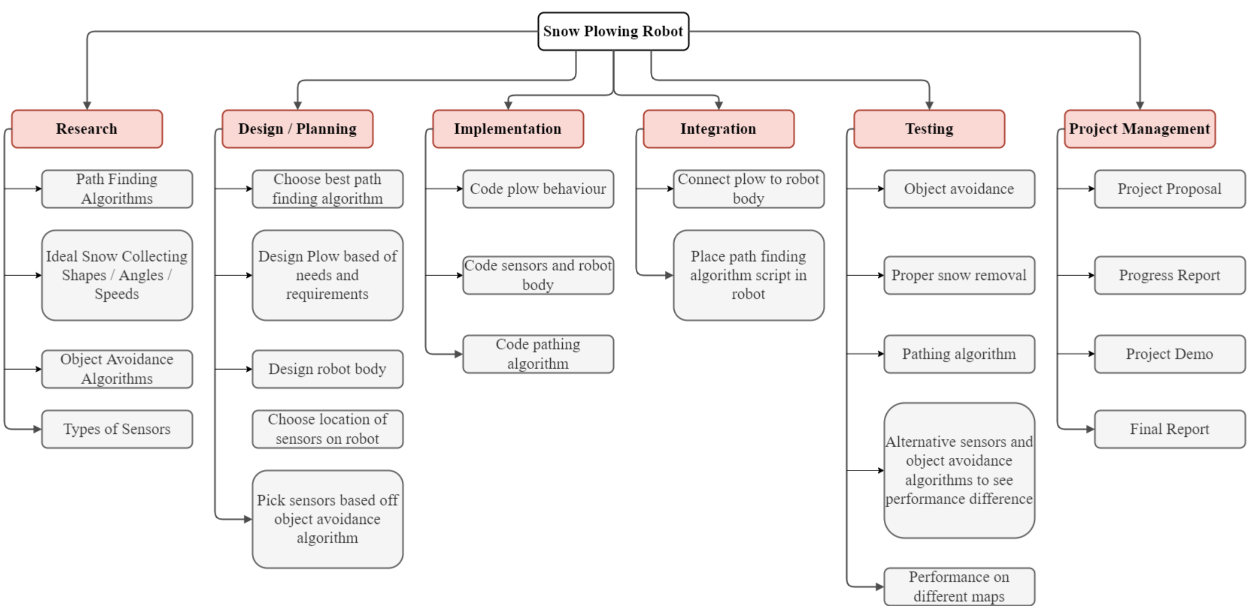


Figure 1: Work Breakdown Structure

A work breakdown structure was developed to help plan out the project development life cycle of the snow plowing robot as shown above in figure 1. This chart depicts the 6 main stages that have been set. The first stage, research, will be dedicated to gaining further knowledge of the available sensors, object avoidance algorithms, and ideal snow plow shapes and sizes. This stage has a 1 week timeframe. The designing/planning stage is for deciding how the robot will be built based on the functional requirements and gathered information. This stage will also be about a week long. The implementation and integration is application of building and coding the simulated snow removal robot. This is where the plow and body will be connected and functionally coded. The selected object avoidance algorithm script will be developed and employed into the robot. This will be a few weeks long as shown in Figure 3, the Gantt chart. Testing will be the final development stage which will confirm that all functional requirements have been met and the robot completes its task properly. The final stage is the project management stage. This stage takes part through the project lifecycle with different deliverables being due throughout the term.

Testing

1. Checking that the robot remains within the size requirements provided by the project description.
2. Test that the robot can remain within the enclosing path, without any snow, with snow, and with both snow and objects. Also, test around the parking space if it is considered a different color than the path.
3. Testing different possible solutions and comparing snow cleared
4. Testing different plow shapes and sizes to find the most effective one given the clearing path.
5. Testing different orientations and locations of sensors
6. Using stubs to test function with missing modules

7. Testing different shapes and colors of obstacles and snow amount
8. Test different tire sizes for optimal performance in snow and without snow.
9. Test different tire friction / torque so tires can push as much snow as possible.

Schedule

Schedule Network Diagram:

ES: Earliest day activity can start

LS: Latest day activity can start

EF: Earliest day the activity can finish

LF: Latest day activity can finish

No.	Activity	ES	EF	LS	LF
1	Project proposal	1	3	2	4
2	Research	4	10	5	15
3	Familiarize with tools	10	15	15	22
4	Code stubs	16	20	23	27
5	Initial integration testing	20	23	27	30
6	Project progress report	20	28	27	38
7	Test Integrated robot	25	29	30	34
8	Finalize code	29	32	36	38
9	Final report	32	35	38	45

Table 1: Schedule Network Diagram Table

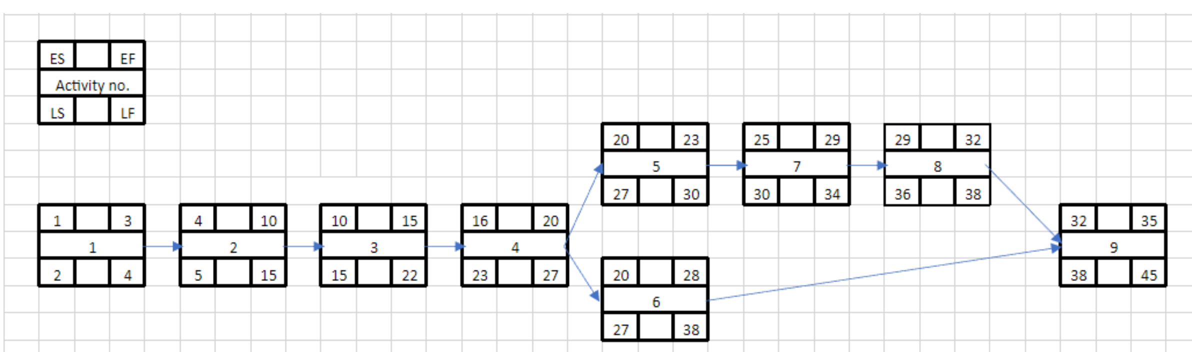


Figure 2: Schedule Network Diagram

Proposed Gantt Chart Timeline:

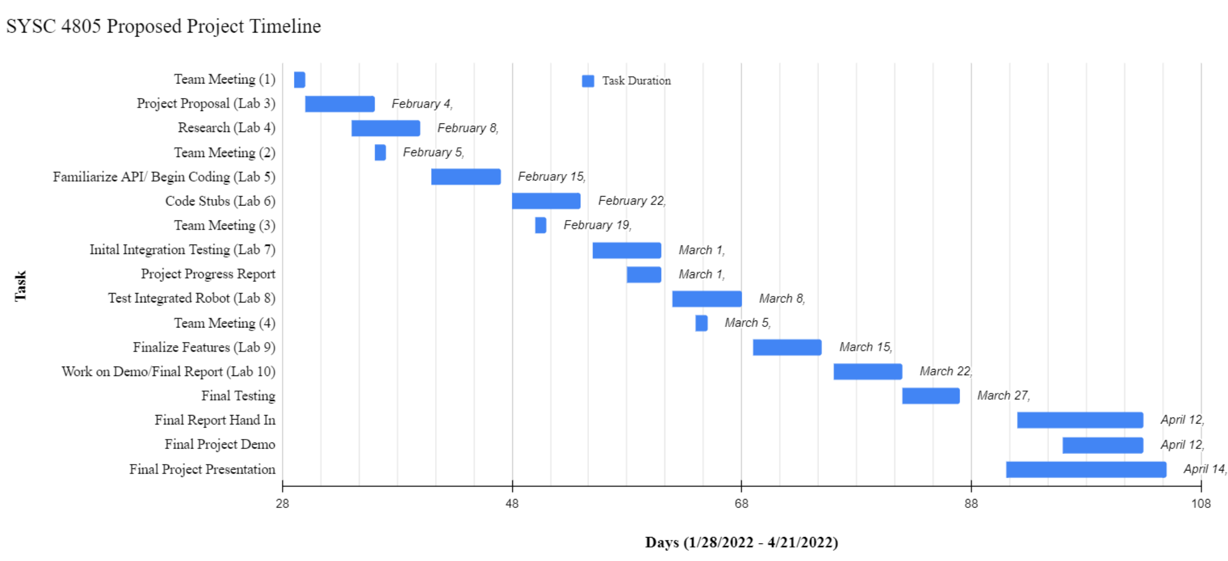


Figure 3: Gantt Chart of Deliverables

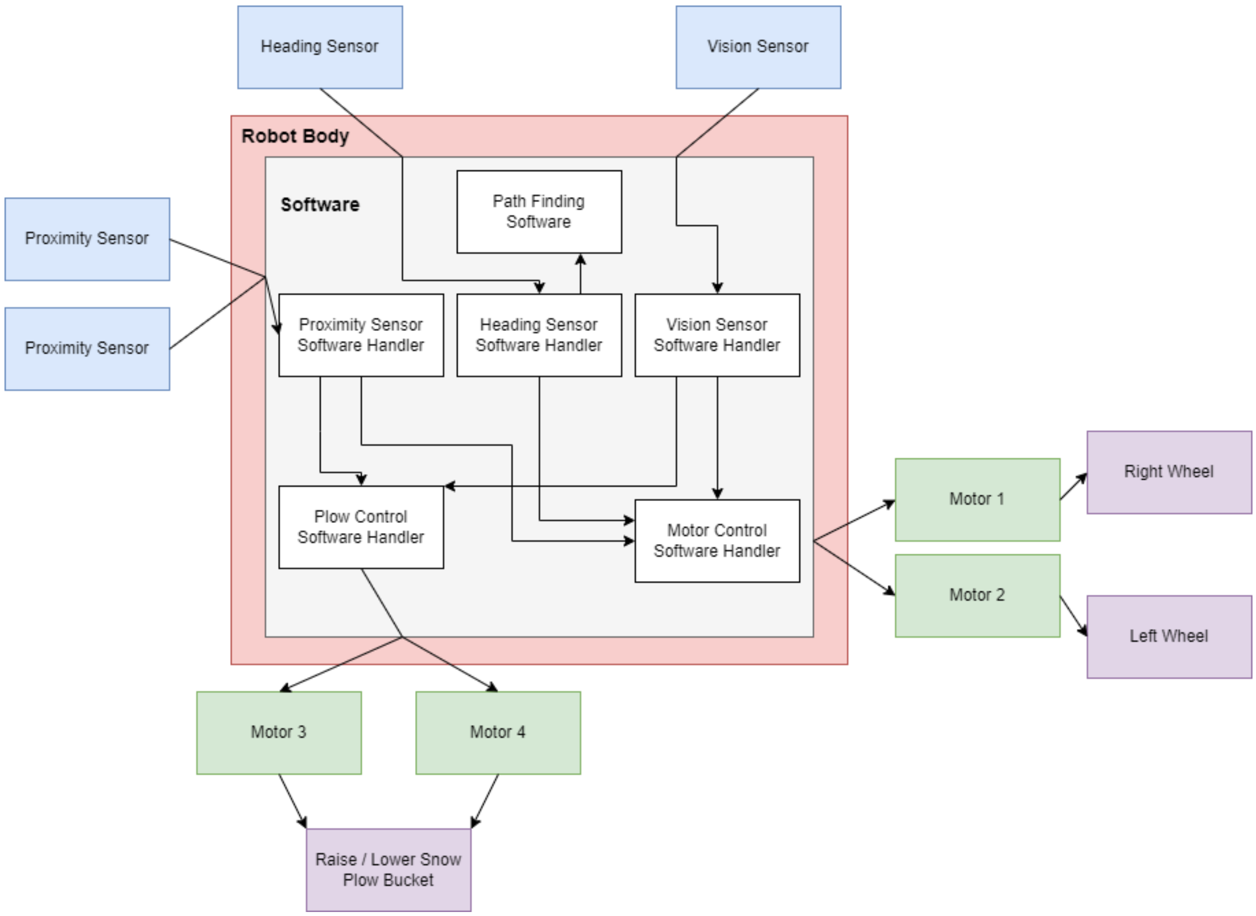
Figure 3 above illustrates the projected timeline for the project. Each week there is a dedicated 4 hour lab period to work on the robot. Each lab has been broken down into specific tasks to mitigate wasted time and confusion. Occasional team meetings will also occur to connect with group members and communicate what progress has been made. Finally, adhering to the project requirements, the due dates for project deliverables such as progress reports, and project demonstrations have also been included.

Human Resources

Activity	Responsible	Approver
Research on obstacle avoidance	Dorian Wang	Nafis Ul Haque
Research mapping algorithms	Moonis Mohammad	Chase Badalato
Research snowplow design	Chase Badalato	Moonis Mohammad
Research robot body design	Nafis Ul Haque	Dorian Wang
Research available sensors	Dorian Wang	Chase Badalato
Implement Robot Body	Nafis Ul Haque	Chase Badalato
Implement Snow Plow	Chase Badalato	Nafis Ul Haque
Code mapping algorithm	Moonis Mohammad	Dorian Wang
Code plow behavior	Dorian Wang	Nafis Ul Haque
Test Robot Plow	Chase Badalato	Dorian Wang
Test Robot mapping algorithm	Nafis Ul Haque	Chase Badalato
Test robot object avoidance algorithm	Dorian Wang	Nafis Ul Haque
Test sensor functionality	Moonis Mohammad	Chase Badalato

Table 2: Human Resources

Overall Architecture



State Chart

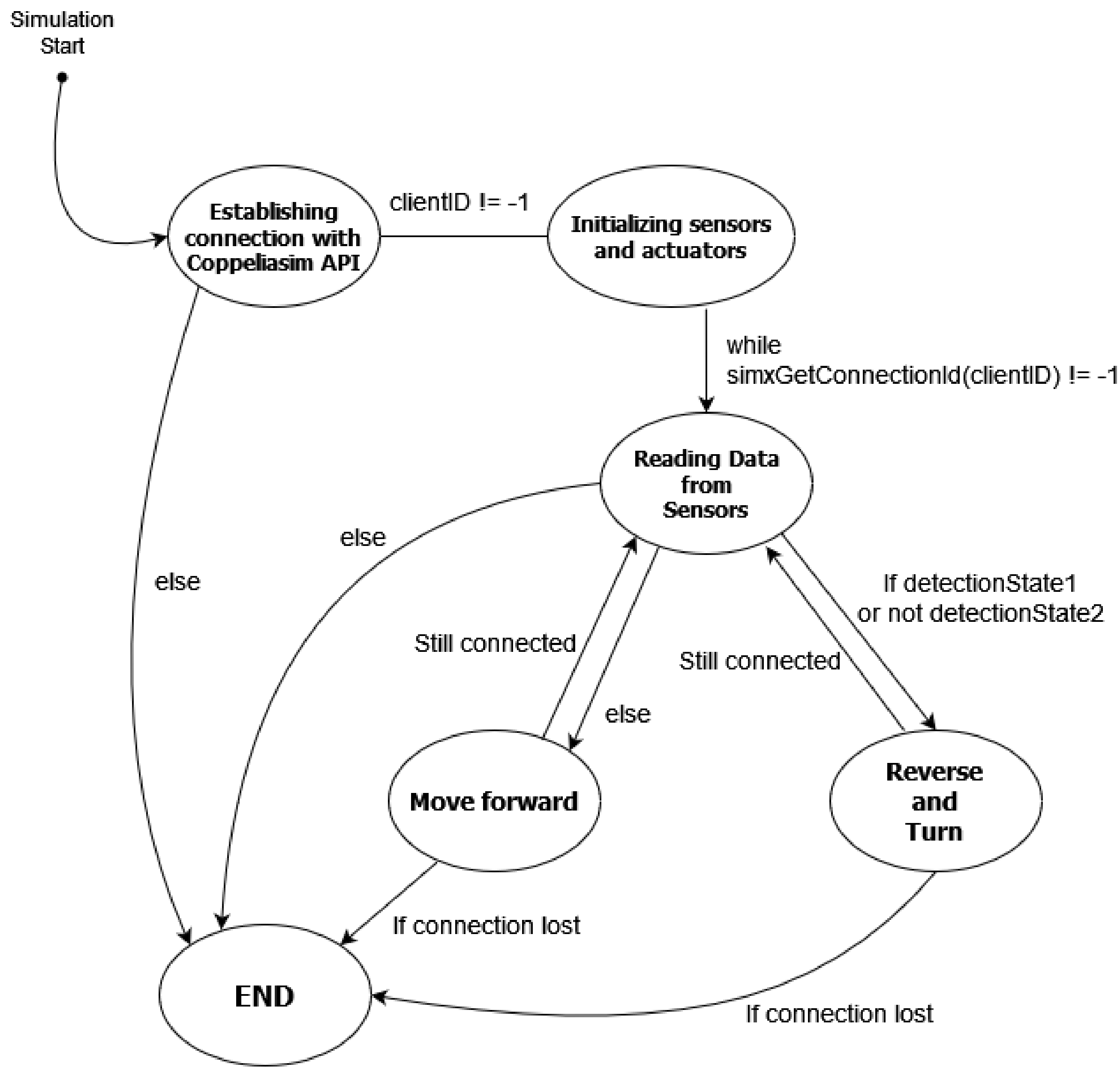


Figure 4: State Diagram

Sequence Diagram

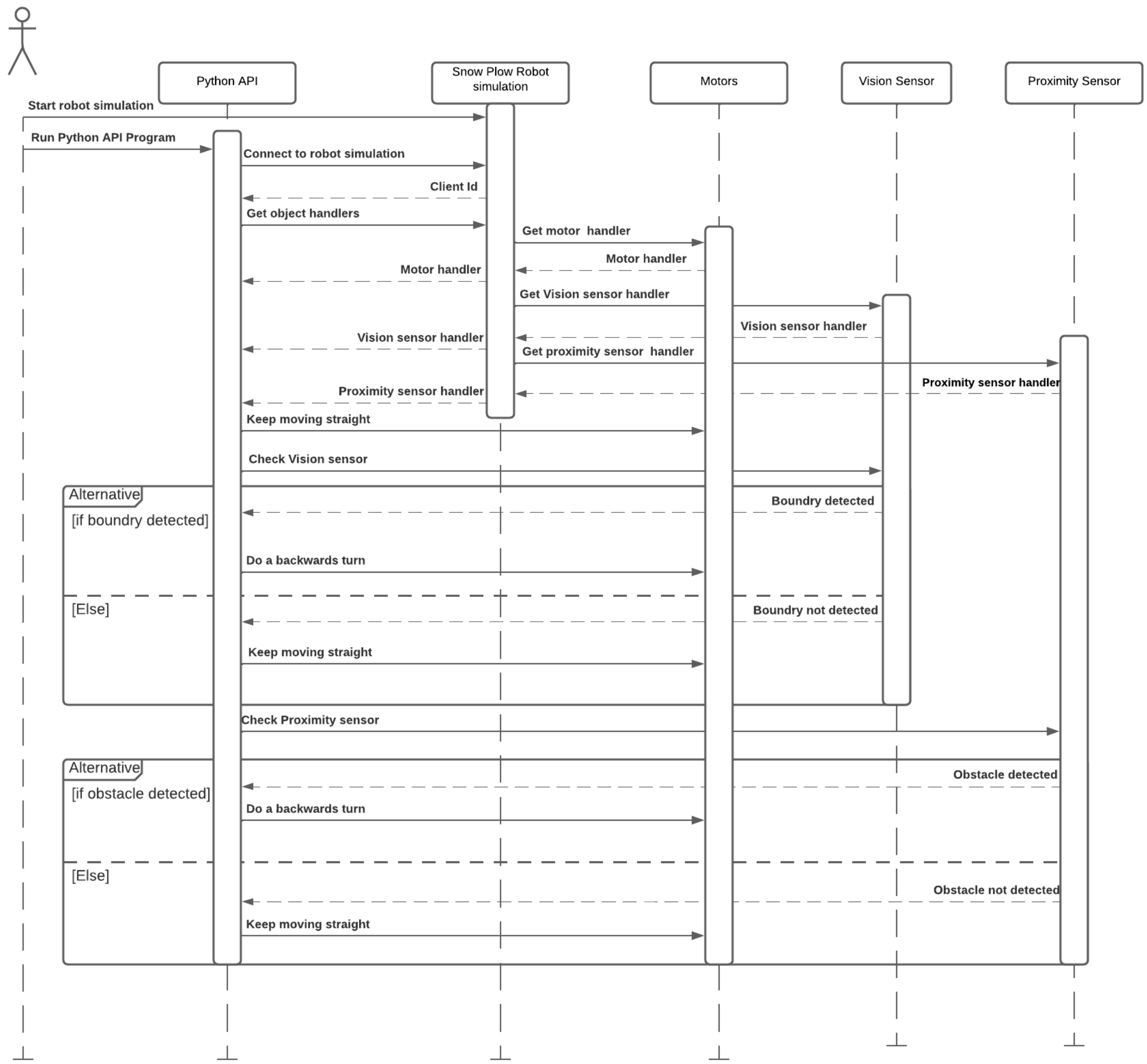


Figure 5: Sequence Diagram

Project Budget

	Units Planned	Units in Use	Company	Component Information	Planned Value ($)	Actual Value ($)
Proximity Sensor (Ultrasonic, 10-250 cm)	1	0	Adafruit	Link [1], Datasheet	$10.00	$5.79 (0 units)
Proximity Sensor (infrared lidar, 10m)	1	1	SparkFun Electronics	Link [2], Datasheet	$100.00	$100.76 (1 unit)
Heading Sensor (magnetic field sensor)	1	0	Memsic Inc.	Link [3], Datasheet	$10.00	$2.33 (0 units)
Vision Sensor	1	1	ESPROS Photonics AG	Link [4], Datasheet	$20.00	$16.87 (1 unit)
Motor (Rotational Servo)	4	2	Adafruit	Link [5], Datasheet	$80 (4 units)	$35.02 (2 units)
Total	**8**	**4**	—	—	**$220.00**	**$152.65**

Table 3: Project Budget

Budget at Completion = Sum of Planned Value = $220.00

Earned Value (EV) = PV of completed tasks = ($100 + $20 + $20 x 2) = $160

The Earned Value is greater than the Actual Value so this helps to demonstrate that our project is currently on track to costing less than our budgeted amount. Table 3, above, links a real life component that would be used on the robot if it was not simulated. These sensors used are: 2 proximity sensors, a heading sensor, a vision sensor, and 4 motors. At the time of the Progress

Report some components have not been implemented, and therefore have not been included in the Actual Value column.

GitHub Repository

The GitHub repository can be found here. It contains all of the current code along with the Project Proposal.

Design Triggers

As our current design has almost no concept of time, it is obviously not time-triggered. The driving python script should run as fast as the simulation allows it to, which may lead to inconsistent timing of events. While the system is not quite like an event driven program, it is similar enough with the way it changes behavior in regards to an event (detected object or line) that I would be willing to call it that.

References

- [1] "4007," *DigiKey*. [Online]. Available: https://www.digikey.ca/en/products/detail/adafruit-industries-llc/4007/9857020. [Accessed: 04-Mar-2022].

- [2] "Sen-15776," *DigiKey*. [Online]. Available: https://www.digikey.ca/en/products/detail/sparkfun-electronics/SEN-15776/10650801?s=N4IgjCBcoCwExVAYygMwIYBsDOBTANCAPZQDaI8A7AGyUwgC6hADgC5QgDKrATgJYA7AOYgAvoTABOAByTEIFJAw4CxMiAAMjFu0hdegkaONA. [Accessed: 04-Mar-2022].

- [3] "MMC5633NJL," *DigiKey*. [Online]. Available: https://www.digikey.ca/en/products/detail/memsic-inc/MMC5633NJL/12171925.

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- [4] "EPC611-CSP24-001," *DigiKey*. [Online]. Available: https://www.digikey.ca/en/products/detail/espros-photonics-ag/EPC611-CSP24-001/10516869. [Accessed: 04-Mar-2022].

- [5] "154," *DigiKey*. [Online]. Available: https://www.digikey.ca/en/products/detail/adafruit-industries-llc/154/5774222. [Accessed: 04-Mar-2022].