SYSC 4805

Robot Task Project - Snow Plough

Team Laser Lemon

Proposal

February 4th, 2022

Group#: 3

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1 Project Charter

1.1 Overall Objective

The overall objective is to design an autonomous snow plough robot using *CoppeliaSim* that will clear the snow off an area enclosed by a closed path while avoiding fixed and moving obstacles.

1.2 Overall Deliverables

The core deliverable of the project is the *CoppeliaSim* model file which implements the final design for the snowplough robot. The model file contains the physical design of the plough as well as the scripts which control the robot's behaviour. The scripts will implement the logic and algorithms necessary to react to sensory input and direct the robot's path to clear as much of the snow as possible within the 5-minute simulation window. Accompanying this model file, other deliverables will focus on documentation and demonstration. For documentation a progress report will be completed midway into project development. There will also be a final-report-documentation deliverable which will summarise all work completed, each member's contributions and describe the end product. Concerning the demonstration, there will be a demo deliverable showing the robot's clearing efficacy on the test maps, and a final project presentation to summarise all the work done while detailing the ultimate result.

2 Scope

2.1 Requirements

The project must adhere to a number of requirements and constraints. The following list serves as a written agreement between the group members on the specifications that the final deliverable will meet. The requirements are as follows:

- The robot shall be no larger than 0.5 x 0.8 x 1 metres at the start of the simulation, including the custom plough component.
- The robot shall be no larger than 1 x 0.8 x 1 metres at any time during the simulation, including the custom plough component.
- The robot shall have a plough component to push snow spheres outside of the highlighted perimeter.
- The robot shall be able to differentiate between obstacles and snow.
- The starting position of the robot shall be (x, y, z) = (0m, -6.25m, 0m).
- The robot shall not exceed a maximum speed of 2 m/s.
- The robot shall detect and avoid obstacles
- The behaviour of the robot shall be written in Python, with support functions written in Lua as needed to integrate unsupported functionality.
- For each sensor the robot possesses, a real-world equivalent sensor shall be documented.
- The robot simulation time shall not exceed 5 minutes.
- The robot shall avoid falling off the edges of the test map.

2.2 Work Breakdown Structure (WBS)

2.2.1 WBS Diagram

A work breakdown structure (WBS) is pictured below in Figure 1. The diagram displays a hierarchical decomposition of the entirety of the work to be completed for the project. The work has been divided into four parts; Project Management, Modelling and Design, Testing and Evaluation, and Deliverables.

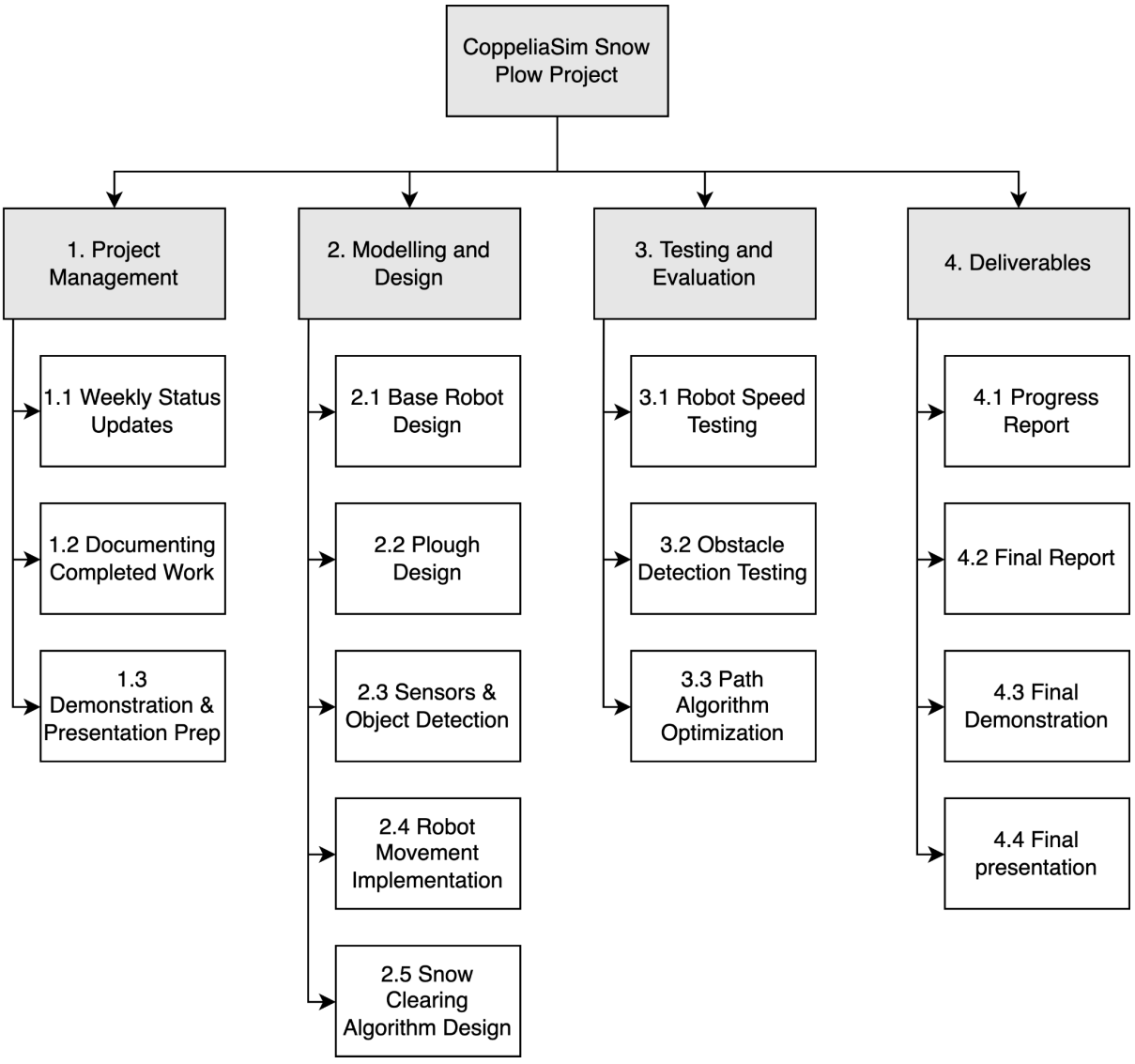

Figure 1: Work Breakdown Structure for the Snow Plough Robot Project

2.2.2 WBS Dictionary

Accompanying the Figure 1 WBS, pictured below is the WBS dictionary. The dictionary (shown in Table 1) provides specific details for each terminal element, including descriptions, constraints and quality requirements.

Terminal Element #	Work Description	Constraints	Quality Requirements
1.1 - Weekly Status Updates	- Consists of updating communication through Discord & follow-ups with the T.A. in weekly lab meetings	- Each member must contribute	- Team members are expected to maintain consistent communication
1.2 - Documenting Completed Work	-Document any tasks, research, algorithm completed	-Team members must follow the gantt chart and schedule network diagram to complete tasks by required deadlines	- Ideally work is documented by individual that completed it
1.3 - Demonstration & Presentation Prep	- Meetings to go through and prepare presentations and the demonstration	- Must be completed reasonably before the presentation due dates	- Clear and effectively describe work accomplished
2.1 - Base Robot Design	-Identify and implement the components required for the base robot design	- Robot cannot be larger than 1x0.8x1 metres (includes plough).	-Robot must be able to move -Robot components must remain attached to the robot body when the robot moves
2.2 - Plough Design	-Identify and Implement the components required for the plough design	- Robot cannot be larger than 1x0.8x1 metres (includes plough).	- Plough must be designed for optimal snow moving
2.3 - Sensors & Object Detection	-Identify and Implement appropriate sensors so that the snow plough robot can follow a closed path and avoid obstacles -Proximity and vision sensors are to be used	- Must be able to differentiate between obstacles and snow - Must have real world equivalent sensor - Scripts will be written in python	-Sensors must be able to detect paths, moving and fixed obstacles
2.4 - Robot Movement Implementation	- Involves having the robot properly move through the simulation environment	- Robot cannot fall off the edge of the test map - Robot cannot exceed 2 m/s	-Robot must follow a closed path
2.5 - Snow Clearing Algorithm Design	-How the robot uses the plough to move the snow out of the arena	- Robot cannot collide with obstacles	
3.1 - Robot Speed Testing		- Simulation time cannot exceed 5 minutes	
3.2 - Obstacle Detection Testing	-Test to ensure that the robot does not hit both fixed and moving obstacles	-Obstacle avoidance algorithm must be correctly implemented	-Obstacle avoidance algorithm must be designed to avoid both fixed and moving obstacles
3.3 - Path Algorithm Optimization	-Test to ensure that the robot follows a closed path	-Path finding algorithm must be correctly implemented	-Robot must be able to follow any closed path
4.1 - Progress Report	-Document the progress made in the project	- Due end of lab 6	-Team members follow the Gantt chart and complete the required tasks
4.2 - Final Report	-Document the progress made, the tests performed, the training maps tested and the challenges faced.	- Due end of lab 12	Team members follow the gantt chart and complete the required tasks, tests and training
4.3 - Final Demonstration	-Simulate and demonstrate our snow plough robot on training maps provided	- Due during last two labs	-Robot must be able to remove most amount of snow in the map while avoiding obstacles
4.4 - Final Presentation	Present our project	- Due during last 4 lectures	-Robot must be working and satisfying all requirements

Table 1: WBS Dictionary for the Snow Plough Robot Project

2.3 Testing

The system shall be tested rigorously to ensure that all agreed upon requirements are met as documented in Section 2.1. We plan on conducting the following tests:

- Unit Testing
    - Test that the robot can detect non-moving obstacles
    - Test that the robot can detect moving obstacles
    - Test the robot's path finding algorithm
    - Test the robot's obstacle avoidance algorithm
    - Test that the robot can detect the path
    - Test that the robot can move snow outside of the detected path
- Performance Testing
    - Record how the robot performs on training map 1
    - Record how the robot performs on training map 2
    - Record how the robot performs on training map 3
    - The robot should be able to plough the snow outside the arena in a maximum of 5 minutes for all training maps
- Stress Testing
    - Test at what speed the robot can no longer reliably detect a moving obstacle
- Integration Testing
    - Test that the robot movement control and plough control modules work together

The unit tests will be performed by measuring the robot module's performance on *CoppeliaSim* scenes generated by a team member.

If the robot can successfully pass the tests outlined above, then it behaves as expected and should successfully remove the snow from the testing maps in the time limit.

3 Schedule

3.1 Schedule Network Diagram

The schedule network diagram for the *CoppeliaSim* Snow Plough project is depicted in Figure 2 below. The diagram is a graphical representation of the logical relationships and dependencies among the project schedule activities that are proposed in Section 4.1.

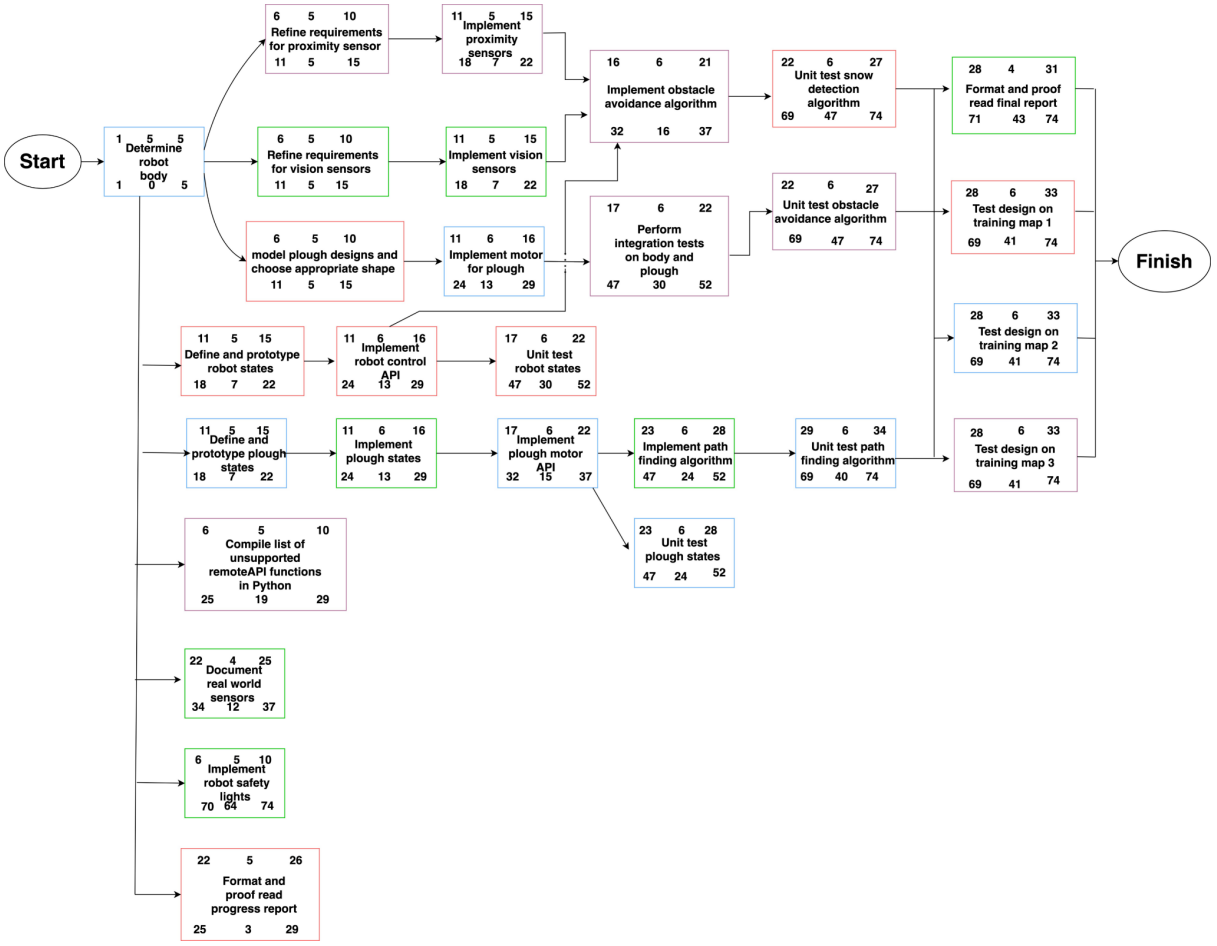

Figure 2: Schedule Network Diagram for the Snow Plough Robot Project

3.2 Gantt Chart

The Gantt chart for the project is provided in Figure 3 below. Each team member has one task assigned each week. A colour coded legend is provided to show which team member is assigned which task. The unit tests for the robot and plough controls require their implementation to be finished before testing can start. A contingency plan is made to allow for an extra week of slack time for implementing the robot and plough control in case any unforeseen problems arise.

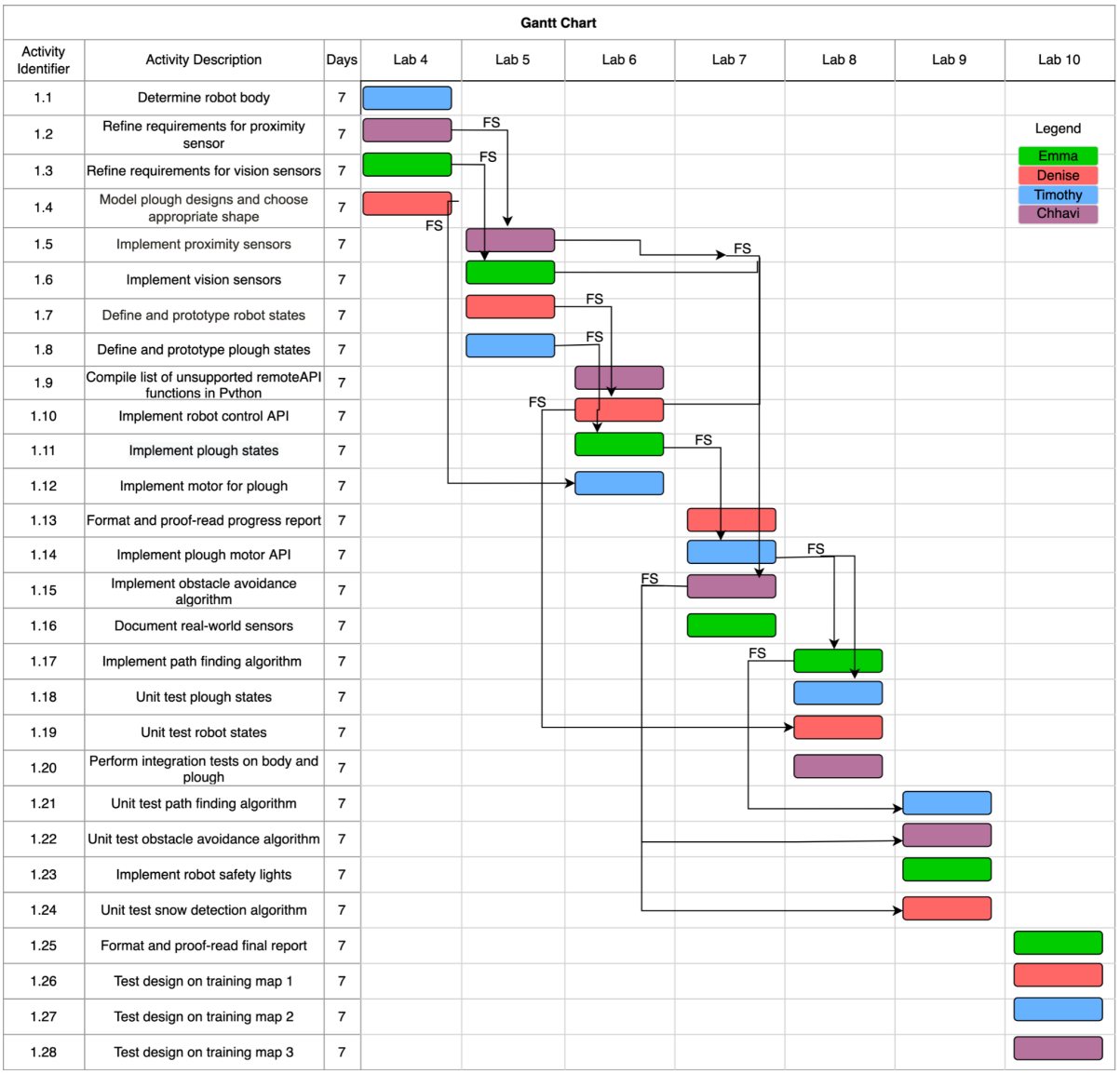

Figure 3: Gantt Chart for the Snow Plough Robot Project

4 Human Resources

4.1 Responsibility Assignment Matrix

Each member in the team was assigned 7 unique tasks that they are responsible for completing and 7 unique tasks they are responsible for reviewing. Figure 4 below shows the responsibility breakdown for the project.

Activity	Denise	Timothy	Emma	Chhavi
Determine robot body style and shape		R	QA	
Refine and document requirements for proximity sensors		QA		R
Refine and document requirements for vision sensors	QA		R	
Define and prototype robot states	R			QA
Document real-world sensor equivalents	QA		R	
Define and prototype plough states		R	QA	
Compile list of unsupported functions in Python API		QA		R
Implement proximity sensor(s)		QA		R
Implement vision sensor(s)	QA		R	
Model plough designs and choose appropriate shape	R			QA
Implement plough control motors		R	QA	
Implement safety lights	QA		R	
Implement plough states	QA		R	
Implement robot states and control API	R			QA
Implement plough control API		R	QA	
Implement general steering and movement control motor functions	QA		R	
Implement obstacle avoidance movement control functions		QA		R
Unit test robot states and control API	R			QA
Unit test plough states		R	QA	
Unit test obstacle avoidance movement control functions		QA		R
Unit test plough control API	R			QA
Unit test movement control (general steering) functions		R	QA	
Perform integration tests on plough and body		QA		R
Test design on training map 1	R			QA
Test design on training map 2		R	QA	
Test design on training map 3		QA		R
Format and proof-read progress report	R			QA
Format and proof-read final report	QA		R	

Legend	
Responsible for completing work	R
Reviewer (quality assurance check)	QA

Figure 4: Responsibility Assignment Matrix for the Snow Plough Robot Project