Project Management Plan

for

MULTI-DISCIPLINARY PROJECT (MDP)

Version 2.0

03/09/2020

GROUP 22

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VERSION HISTORY

Version #	Implemented By	Revision Date	Approved By	Approval Date	Reason
1.0	Calvin He Jia Jie	08/21/20	Sam Jian Shen	08/21/20	Initialize report for MDP
1.1	Sam Jian Shen	08/21/20	Xavier Ho	08/23/20	Formulate and establish available information and facts.
1.2	Keerthan Arularasan	08/23/20	Xavier Ho	08/25/20	Solidify information and updates with respect to MS Team discussion
1.3	Lee Yu Sheng Daniel	08/27/20	Muddineni Krishnavyas	08/27/20	Algorithm Representative update on team's planning and delegation
1.4	Tan Boon Hing	08/27/20	Sam Jian Shen	08/27/20	Android Representative update on team's planning and delegation
1.5	Brighten Tan Yan Hui	08/27/20	Xavier Ho	08/27/20	Arduino Representative update on team's planning and delegation
1.6	Lin Yue	08/27/20	Calvin He Jia Jie	08/27/20	RaspberryPi Representative update on team's planning and delegation
1.7	Chandna Divvij	08/27/20	Muddineni Krishnavyas	08/27/20	Beautify Organization of the Team and adjustment/alignment for better readability
1.8	Xavier Ho	08/28/20	Calvin He Jia Jie	08/31/20	Primary Reviews and changes accordingly
1.9	Muddineni Krishnavyas	08/31/20	Sam Jian Shen	08/31/20	Secondary Reviews and changes accordingly
2.0	Sam Jian Shen	09/01/20	Xavier Ho	09/03/20	Final Review and Ready for Submission

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1 INTRODUCTION

1.1 PROJECT OBJECTIVES

This project required a team to design a robot. There will be leaderboard challenges lasting from week 8 to week 10. The grading of the challenges will be judge base on the performance measure as shown below:

- Image Recognition
  - The robot must be able to identify a set of given 15 images allocated in the arena
  - The robot must be able to provide the correct 2-dimension coordination all the image locations.
- Exploration
  - The robot must be able to explore an unknown arena within a dimension of 2m length, 1.5m width, 0.15m height.
  - The robot must be able to avoid a collision from randomly placed obstacles in the arena.
- Fastest Goal Time
  - After exploration, the robot must be able to decide the shortest path, direction and position to move from an initial point A to ending point B.

2 SCOPE

The various aspects of developing a working robot for the Multi-Disciplinary Project include a mixture of both hardware and software, ranging from Arduino, Raspberry Pi (RPi), Android and Algorithms. Throughout the group's journey towards the construction and development of the robot to compete in various leaderboard challenges, the group would be documenting the project through a project video and a wiki site. Following is a detailed description of what will be accomplished in the multiple disciplines throughout the group's MDP journey:

Arduino: To design and construct the robot hardware, develop Arduino program for calibrating and ensuring consistency, meaning that the robot should move in a direction as expected (e.g. the robot should move in a straight line when programmed to do so. In the next phase, the robot would read data from sensor inputs consisting of InfraRed sensors for navigation and a camera for image recognition, then interpret instructions received from the RPi module through a serial connection and act accordingly, based on the RPi and Algorithm programs.

Android: To engineer a responsive and interactive mobile application on Android platform to be used as a controller for the robot, to navigate seamlessly via Bluetooth connection. The application should provide robust Bluetooth device discovery and communication with other Bluetooth devices. The application should be able to transmit data between the Android device and the RPi which enables the application to send commands to the RPi and receive

information from the RPi. The application's GUI should provide inputs to issue commands to the robot. The application must be able to display the robot's status and reflect the physical arena map in a graphical user interface, in real-time by reading and interpreting JSON strings received from RPi.

Algorithms: To first develop a simulation platform that can enable the simulation of the various navigation methods. Next, to implement the autonomous navigation for the robot in 2 aspects, Exploration and Shortest Path. The Exploration algorithm should provide instructions on how to navigate and traverse around the arena, collecting as much information about it. Next, the Shortest Path algorithm should process the data collected and output instructions on how the robot should reach the destination in the shortest path possible.

Raspberry Pi: To become a communication hub between the hardware, which collects information and executes instruction, and the backend algorithm, which receives information, processes and outputs instruction via a multi-threaded process. To connect the multiple devices, Android tablet via Bluetooth, PC via Wi-Fi and Arduino via USB. Next would be to integrate the camera module to the RPi, giving it the functional ability for image detection and recognition.

2.1 ASSUMPTIONS/CONSTRAINTS

Assumptions

1. All hardware resources are in good working condition till the end the project duration.
2. Hardware materials that become faulty can be replaced with new parts.
3. Laboratories are free for access if within free access hours and office hours.
4. Power bank units can power respective devices efficiently and will sufficiently last for the entire duration of robot runs.
5. Power bank will also be able to maintain and hold its charge throughout the period of 10 weeks of the leaderboard.
6. All team members are to watch online lectures and thus have an idea of what technical knowledge is expected of them before attempting their individual checklist.
7. All team members are expected to commit at least 6 hours per week for this project.
8. All team members are in a healthy condition throughout the duration of this project.
9. There is internet access for all team members to platforms such as 'Blackboard' for project information, 'Microsoft (MS) Teams' for project meetings, discussions and progress tracking, 'WhatsApp' for group chat, GitHub for team's source control repositories.
10. Any team member who failed to respond to a pending response/vote/polling within 48hrs shall be deemed to have agreed with majority's response. No further discussion shall be given thereafter. This is to ensure continual progress towards the goal of the project.

11. In the event, polling or voting is equal, the final decision will be up to the project manager.

Constraints

1. Labs are only available during office hours, which limits the testing time available for each team.
2. Lab access is also restricted to the availability as other classes would have to be prioritized over free access usage.
3. In the event of the project manager not able to commit due to unforeseeable circumstances, the project manager will have the right to appoint an existing team member to temporary take over the role of the project manager.
4. The testing and calibration must be done in a fair arena since the scale and measurement different from one another, thus such an arena will be bounded to a designated arena only to ensure consistency.
5. The project manager delegates tasks to members according to their best interests. However, the team member may face a role in which they are unfamiliar or less keen but must bear with it. Thus, hinders the performance and may lead to a greater magnitude of error when estimating time to complete a task.

2.2 WORK BREAKDOWN STRUCTURE (WBS)

S/N	Work (Activity/Task)	Description	Efforts Estimation (days)	Dependencies
Initial Phase				
1.0	Team Formation	Team formation and Allocation of Roles and Responsibilities	1	
1.1	Requirement Elicitation	Team members to understand their roles and responsibilities on their assigned roles	3	
1.2	Establish Foundation and Communication Channels	Setting up Microsoft Teams as main communication channel, documentation and central file sharing hub. Creating of GitHub and GitLab repositories for source code.	1	
1.3	Project Plan Phase 1	Detailing of project plan's scope, assumptions, roles and responsibilities.	3	1.1
1.4	Project Plan Phase 2	Detailing of project plan's team strategy and time management	3	1.3
1.5	Project Plan Phase 3	Detailing of project plan's work breakdown structure	3	1.4
1.6	Project Plan Phase 4	Detailing of project plan's risk management	3	1.5
Arduino				
2.0	Requirement Elicitation	Perform requirement elicitation and understand the scope of their role	3	

S/N	Work (Activity/Task)	Description	Efforts Estimation (days)	Dependencies
2.1	Robot Initial Design Planning	Planning of how the hardware components such as sensors, batteries, motors should be mounted and constructed.	3	
2.2	Robot Assembly (Sensor and Motor assembly)	Assembly of motors and sensors on robot as well as testing to ensure functionality	3	2.1
2.3	Sensor Calibration (learning)	Understand how sensors are calibrated.	3	2.2
2.4	Sensor Calibration (application)	Implement functions to calibrate the sensors on the robot to correctly return distance to obstacles, to be performed before every run.	3	2.3
2.5	Motor Calibration (learning)	Understand how motors are calibrated.	3	2.4
2.6	Motor Calibration (application)	Implement functions to calibrate the motors on the robot to perform accurate straight-line and rotational motion, to be done before every run	3	2.5
		Raspberry Pi		
3.0	Requirement Elicitation	Perform requirement elicitation and understand the scope of their role	2	
3.1	RPi OS set-up	Reformatting the SD Card and flashing a new OS onto the RPi	1	3.0
3.2	Communication Channel set-up	Set up the RPi as a Wi-Fi access point to be remotely accessed through SSH. Set up a Bluetooth connection between RPi and Android tablet.	2	3.1
3.3	Installation Of Packages	Installation of packages required for various RPi functionalities and requirements, including communication, multi-threading and image recognition.	1	3.1, 3.2
3.4	Android communication module	Implement a module facilitating communication with Android via Bluetooth (rfcomm)	2	3.2, 3.3
3.5	Arduino communication module	Implement a module facilitating direct communication with Arduino via USB cable (ACM protocol)	3	3.2, 3.3
3.6	Algorithm communication module	Implement a module facilitating communication with PC via Wi-Fi (IP socket programming)	3	3.2, 3.3
3.7	Multi-threading (learning)	Understand how multi-threading module should be implemented.	3	
3.8	Multi-threading (Application)	Implement multi-threading module interconnecting PC, Arduino and Android.	3	3.4, 3.5, 3.6, 3.7

S/N	Work (Activity/Task)	Description	Efforts Estimation (days)	Dependencies
3.9	Image recognition module 1 (learning)	Understand how image detection and recognition should be implemented.	3	3.1, 3.2
3.10	Image recognition module 1 (application)	Develop a module to detect and recognize images on the obstacles in the maze, utilizing OpenCV library in Python.	3	3.9
3.11	Image recognition module 2 (application)	Train model continuously using different epochs.	3	3.10
3.12	Image recognition module 3 (application)	Test and improve model to ensure consistency and accuracy.	3	3.11
Android				
4.0	Requirement Elicitation	Perform requirement elicitation and understand the scope of their role	2	
4.1	Recap Knowledge Required (Languages syntax, OO Concepts and IDE)	Revision on the knowledge require on android such as JAVA, Object Oriented Programming (OOP) concepts, setting up the android studio for the application.	3	4.1
4.2	Recap Knowledge Required (Framework, Collaboration platform)	Revision on the knowledge related to collaborative development platform such as GitLab, familiar with software architecture used for this project.	3	4.2
4.3	Android app prototyping	Create a LO-FI design of the application	2	
4.4	Establish Bluetooth connectivity	Establish Bluetooth connection module to allow bi-directional data transfer with a functional GUI	2	4.2
4.5	Develop Controller	Develop an interactive UI control to support physical robot movement via Bluetooth communication.	3	4.4
4.6	Display Status of Robot	Display status of Robot via parsing the JSON string received	2	4.3, 4.4
4.7	Develop GUI to store persistent string commands	Develop functional GUI that provides two buttons that supports persistent user reconfigurable string commands to the robot.	2	4.3
4.8	Develop 2D GUI of the arena (Manual)	Develop dynamic 2D GUI of the arena which can be updated manually via user interaction	2	4.3
4.9	Develop 2D GUI of the arena (Automatic)	Develop dynamic 2D GUI of the arena which can be updated automatically via user interaction	3	4.3

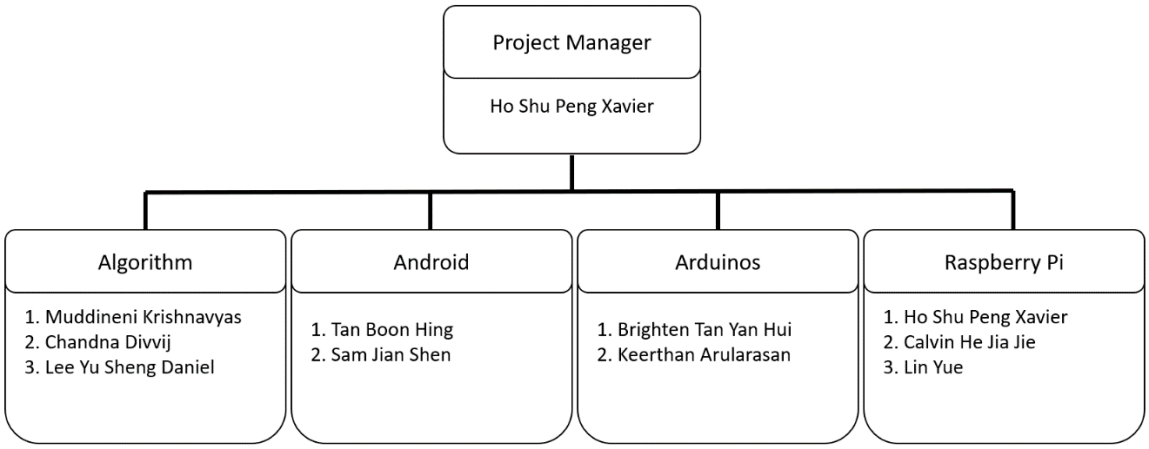
S/N	Work (Activity/Task)	Description	Efforts Estimation (days)	Dependencies
4.10	Develop GUI for Waypoint & Start point selection	Develop GUI for the user to select Waypoint and robot's start point via touch selection in arena grid.	2	4.3
4.11	Display image ID on arena grid	Display image ID on arena via parsing the JSON string received.	1	4.3,4.7
		Algorithms		
5.0	Requirement Elicitation	Perform requirement elicitation and understand the scope of their role	2	
5.1	Research on Exploration Algorithms	Explore different kinds of search algorithms to select and modify for the robot for optimal results.	2	5.0
5.2	Development of the maze simulator	Implement a virtual simulator in python to recreate the maze environment to run and test the exploration algorithms.	3	
5.3	Exploration algorithm design	Design and implement exploration algorithms in Python	3	5.2
5.4	Shortest path algorithm design	Design the shortest path algorithm	3	5.2
5.5	Shortest path algorithm Implementation	Implementation of the shortest path algorithms in Python	3	5.2, 5.3, 5.4
5.6	Test Algorithms	Implementing the respective designed algorithms on the maze simulator and testing out.	3	5.2, 5.4, 5.5
5.7	Optimize the algorithms for the specified constraints	Optimize the developed algorithms to meet the exploration and shortest path objectives.	2	5.2, 5.5, 5.6
5.8	Establish communication with RPi	Establish a communication channel with RPi	2	5.5, 5.6
		Integration and Testing Phase		
6.0	Initial Integration	Integrate RPi, Arduino and Android systems	2	
6.1	Robot Calibration (Test 1,2,3)	Calibrate robot and its systems during test phase	2x3	6.0
6.2	Robot Test Arena Run (Test 1,2,3)	Testing to be performed, with further calibration to be made during test phase	1x3	6.0,6.1
6.3	Post-Test Review & Enhancements (1,2,3)	Using AGILE framework, review and identify aspects that can be further improved during test phase.	2x3	6.0,6.1,6.2
		Final Showdown		
7.0	Pre-Challenge Robot Calibration 1	Calibrate robot and its systems before leaderboard challenge 1	2	

S/N	Work (Activity/Task)	Description	Efforts Estimation (days)	Dependencies
7.1	Leaderboard Challenge 1	Challenge the leaderboard with our best robot in the arena!	1	
7.2	Post-Challenge Review & Enhancements 1	Using AGILE framework, review and identify aspects that can be further improved before leaderboard challenge 2	2	7.1
7.3	Pre-Challenge Robot Calibration 2	Calibrate robot and its systems before leaderboard challenge 2	2	
7.4	Leaderboard Challenge 2	Challenge the leaderboard with our best robot in the arena!	1	
7.5	Post-Challenge Review & Enhancements 2	Using AGILE framework, review and identify aspects that can be further improved before leaderboard challenge 3	2	7.4
7.6	Pre-Challenge Robot Calibration 3	Calibrate robot and its systems before leaderboard challenge 3	2	
7.7	Leaderboard Challenge 3	Challenge the leaderboard with our best robot in the arena!	1	
		WIKI Blog		
8.0	Familiarity of tools	Understanding how it work such as posting, editing.	1	
8.1	Design of content	Discuss the best arrangement of content that focus on clarity, order of importance, user friendliness when used	3	
8.2	Update content plans	Discuss on (who,when,how) to update the task into WIKI	1	8.1
8.3	Weekly update and review of content to internal repository	Update Wiki progressively once every week, entailing updates and changes, documenting technical aspects of the project. Feedback channel on a weekly basis.	1x11	8.2
8.4	Wrap Up Content and Upload to WIKI	Final Review of the content and ready for submission to WIKI	2	8.3
		Video Showcase		
9.0	Project Video Plan	Design the flow of the video, the theme of the video, draft out the content highlights, video tools used, environment and location consideration for filming.	2	
9.1	Project Video Implementation	Create a project video, showcasing our progress, failures and successes of the team throughout the term.	3	9.0
9.2	Project Video Editing	Integrate all segment of videos into one, add animation, sound effect and other possible video enhancement capability.	2	9.1
9.3	Project Video Review	Update changes base on the feedback.	2	9.2

S/N	Work (Activity/Task)	Description	Efforts Estimation (days)	Dependencies
9.4	Project Video Finalisation	Final review and get ready for video submission	1	9.3

3 PROJECT ORGANISATION

Our MDP team will be further split into 2 to 3 persons per team based on their role as shown in the Project Organization (Figure 1) below. Ho Shu Peng Xavier, from the Raspberry Pi team, will concurrently take up the role of Project Manager throughout the project's lifecycle.



(Figure 1 – MDP Group 22 Organization)

The following table contains the roles and responsibilities of each member.

Assigned Roles	Team Member	Main Responsibilities
Project Manager / Raspberry Pi Developer	Ho Shu Peng Xavier	• Manage team morale and motivation. • Review team progress and enforce key decisions. • Set up RPi communications modules for Arduino. • Assist in implementing multi-threading to coordinate communication between components.
Raspberry Pi Developer	Calvin He Jia Jie	• Set up initial RPi communications such as Bluetooth and Wi-Fi. • Implement multi-threading to coordinate the communication between components
Raspberry Pi Developer	Lin Yue	• Implement image detection and recognition for the given 15 images.
Algorithm Developer	Muddineni Krishnavyas	• Implement shortest path and exploration algorithms • Design GUI to illustrate algorithm execution
Algorithm Developer	Chandna Divvij	• Set up connection between RPi and PC • Assist in shortest path and exploration algorithms

Algorithm Developer	Lee Yu Sheng Daniel	• Generate map descriptors for any map • Implement simulation for time and coverage-limited exploration
Android Developer	Tan Boon Hing	• Display and reflect information about robot's current status and maze environment. • Create GUI for the arena and controller.
Android Developer	Sam Jian Shen	• Create GUI for establishing Bluetooth link between Android tablet and RPi. • Establish and standardize communication protocols between Android tablet and RPi.
Arduino Developer	Brighten Tan Yan Hui	• Assemble robot • Calibrate motors to ensure straight-line motion of the robot • Ensure robot can perform accurate rotations between 720 to 1080 degrees • Implement digital controllers to ensure straight-line motion of the robot
Arduino Developer	Keerthan Arularasan	• Assist in robot assembly • Calibrate all sensors accurately • Coordinate with RPi and Algorithm developers on communication protocols and hardware constraints • Preprocess all sensor inputs for feedback and self-calibration

4 APPROACH

Team's Strategy

This project requires every individual team member's effort who came from different walks of life across multiple disciplines. Despite, working during the time of uncertainty (COVID-19), communication is ever more important, regular online face-to-face meetings and discussions are there to ensure everyone is on the same page.

At the start, it is crucial in getting the right setting and rules from the project. To discuss and delegate the roles and responsibilities of each team member. The team will then have to set a common goal as to what they would like to accomplish in this MDP journey.

Thereafter, as the team is to deliver within a tight 12 weeks schedule, there is a need for continuous planning and development to ensure progressiveness throughout the project.

All in all, the team concludes that the 'Agile' lifecycle framework (Figure 2) would be the most feasible approach in dealing with this project. It is an iterative approach that allows teams to break down large projects or tasks into smaller and manageable tasks tackled in short iterations also known as sprints. In return, our team acquired the ability to adapt to change quickly and deliver high productivity of work.

Alongside this, the team will be using a project manager TeamGantt (Figure 4), for progress tracking and time management to ensure things are up to pace and Agile Sprints are on track. Tasks are broken down into smaller ones and checked with a Simple Iteration Burndown (Figure 3) (with Done included), to identify how the team is progressing.

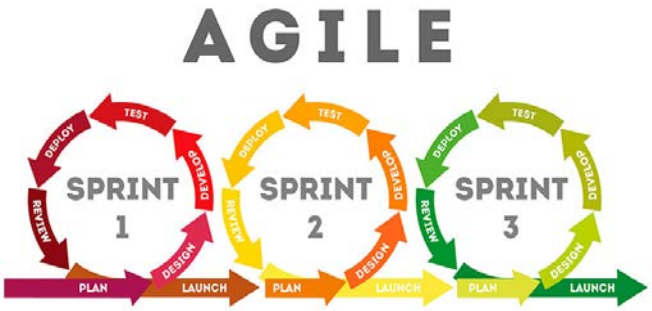


Figure 2 – Agile Methodology

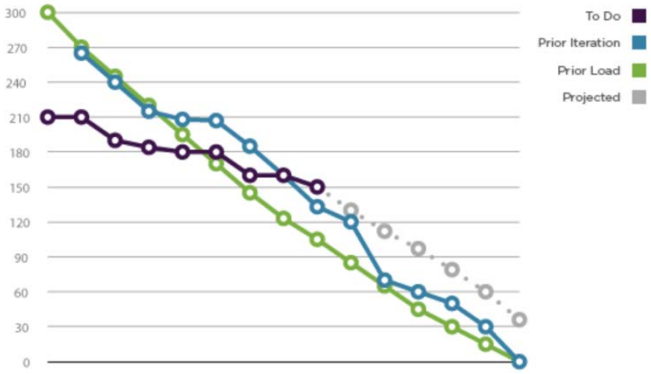


Figure 3 – Simple Iteration Breakdown

Phase	Description
Plan	The team is required to gather initial information, form objectives, scope, requirement, and agenda for every meeting.
Design	The team will need design features and functionalities that are planned for.
Develop	Once the design has agreed. The team will start to implement the hardware and/ or software components.
Test	The team will test the system to make sure all requirements from the planning phase are satisfied, error-free, and produce consistent results.
Deploy	Once testing is completed, the team will integrate all the different components.
Review	The integrated system will be going through quality maintenance throughout. In the event where there are changes in the requirements in the planning phase, the team would then repeat the cycle from the 'Plan' phase.

5 RISK MANAGEMENT

Risk Description	**Mitigation/Contingency Plan**	**Criticality (High/Med/ Low)**
Overdue tasks	1. Each team are given buffer time during the discussion and planning of our project schedule in case of unforeseeable delays. 2. Initially, members are given secondary roles in other fields in the event other divisions within the team require more assistance. 3. The project manager will keep track of team member's progress work via Microsoft Teams	High

Risk Description	Mitigation/Contingency Plan	Criticality (High/Med/ Low)
Inconsistent Performances from devices	1. Work on different with the consideration of inconsistent alternative solutions. Project manager will remind everyone to ensure they will remain aware of such possible issue.	High
Received missing or faulty components	1. During the first 4 academic weeks, should any of the component list be missing/faulty. It should be requested/replaced immediately. 2. During the first 4 academic weeks, Members are required to test components once replaced to ensure the devices are working in condition. 3. After the 4 academic weeks, the team shall purchase the equipment from a suitable vendor. Team will contribute funds equally when making purchase.	Med
Damage of components during	1. The team shall investigate the seriousness of the damage. 2. If the damage does not affect the functional the system, the damage can be ignored. 3. If the damage affects the functional of the system partially, the team will have to think of alternative solutions or have to purchase another one. 4. If the damage affects the functionality of the system fully, the team shall purchase the damaged component immediately.	Med
Unforeseen circumstances	1. In the event where any one of the team members being quarantined due to unforeseeable circumstances such as COVID-19, the progression of the team will likely be delayed and require additional support from the other team. The changes of the role will be the decision either to volunteer or appoint by the project manager.	Med
The time taken to learn unfamiliar programming tools	1. To minimize time taken, project manager has to delegate based on individual's best of interest and expertise. 2. Team member can raise their concerns and issues that they face. The team will try to help those who need it. 3. If the concern or issue is not within the capability of the team to resolve, the team member can approach respectively lab supervisors to consult about the problem.	Low

Risk Description	**Mitigation/Contingency Plan**	**Criticality (High/Med/ Low)**
Tracking on checklist	1. A excel sheet created to act as a record sheet. This help to keep track who is responsible and when it was taken. 2. In the event whereby the person responsible for taking care of a component is not available, a representative of the division can assist to obtain the component if he is contactable.	Low

6 SCHEDULE/TIME MANAGEMENT

6.1 MILESTONES

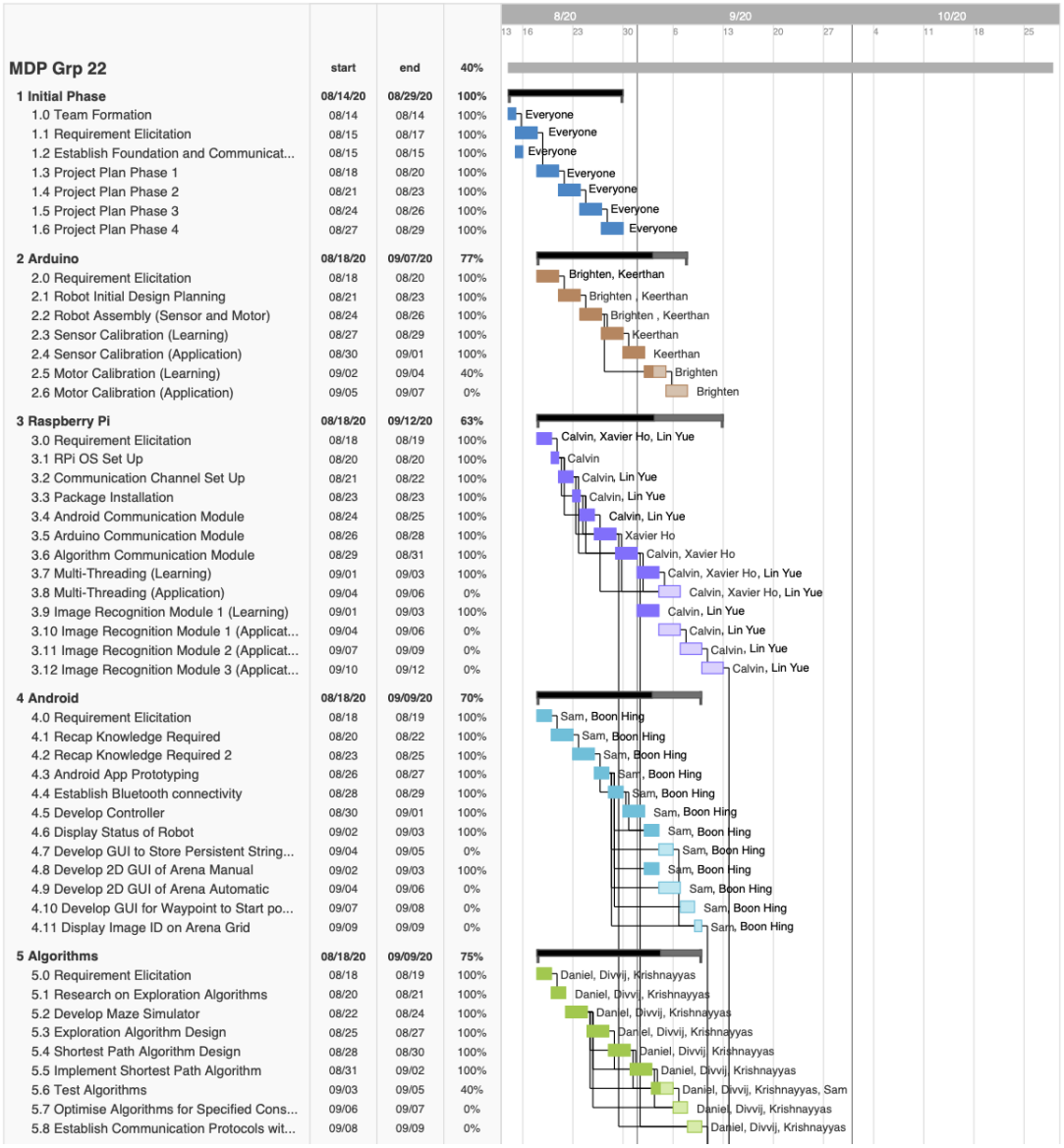
The table below lists the milestones for this project, along with their estimated completion timeframe.

Milestones	Estimated Completion Timeframe
Kickstart Project and Task Delegation	Due on the end of Week 1
Knowledge Gathering and Revision	Due on the end of Week 1
Setup Android Studio Environment	Due on the end of Week 2
Basic Configuration of Raspberry Pi	Due on the end of Week 2
Develop Android UI prototype	Due on the end of Week 2
Robot Design and Layout	Due on the end of Week 2
Project Planning	Due on the end of Week 3
Wi-Fi Communication	Due on the end of Week 3
Bluetooth Communication	Due on the end of Week 3
Arduino Communication	Due on the end of Week 3
Fully assemble robot (with sensors)	Due on the end of Week 4
Established Communication between components	Due on the end of Week 4
Complete robot calibration	Due on the end of Week 4
Implement UI for algorithms	Due on the end of Week 4
Display MDF JSON strings into graphical arena grids on Android	Due on the end of Week 5
Implementation of exploration algorithms	Due on the end of Week 5
Generation of MDF hexadecimal strings	Due on the end of Week 6
Arena simulation and exploration trial run	Due on the end of Week 6
Implementation of fastest path algorithms	Due on the end of Week 7
Image Detection and Recognition of set of 15 Images	Due on the end of Week 7
Integrate All-in-One components	Due on the end of Week 7
Robot Test Run	Due on the end of Recess Week
First Leaderboard Challenge	Due on the end of Week 8
Second Leaderboard Challenge	Due on the end of Week 9
Final Leaderboard Challenge	Due on the end of Week 10
Project Wiki Submission	Due on the end of Week 11
Project Video Submission	Due on the end of Week 12

6.2 PROJECT SCHEDULE

The project schedule will showcase all the work breakdowns, ownerships, and task dependencies for all the team members. The team will be using it for task management and progress tracking.

teamgantt
Created with Free Edition



MDP Grp 22	start	end	40%
1 Initial Phase	**08/14/20**	**08/29/20**	**100%**
1.0 Team Formation	08/14	08/14	100%
1.1 Requirement Elicitation	08/15	08/17	100%
1.2 Establish Foundation and Communicat...	08/15	08/15	100%
1.3 Project Plan Phase 1	08/18	08/20	100%
1.4 Project Plan Phase 2	08/21	08/23	100%
1.5 Project Plan Phase 3	08/24	08/26	100%
1.6 Project Plan Phase 4	08/27	08/29	100%
2 Arduino	**08/18/20**	**09/07/20**	**77%**
2.0 Requirement Elicitation	08/18	08/20	100%
2.1 Robot Initial Design Planning	08/21	08/23	100%
2.2 Robot Assembly (Sensor and Motor)	08/24	08/26	100%
2.3 Sensor Calibration (Learning)	08/27	08/29	100%
2.4 Sensor Calibration (Application)	08/30	09/01	100%
2.5 Motor Calibration (Learning)	09/02	09/04	40%
2.6 Motor Calibration (Application)	09/05	09/07	0%
3 Raspberry Pi	**08/18/20**	**09/12/20**	**63%**
3.0 Requirement Elicitation	08/18	08/19	100%
3.1 RPi OS Set Up	08/20	08/20	100%
3.2 Communication Channel Set Up	08/21	08/22	100%
3.3 Package Installation	08/23	08/23	100%
3.4 Android Communication Module	08/24	08/25	100%
3.5 Arduino Communication Module	08/26	08/28	100%
3.6 Algorithm Communication Module	08/29	08/31	100%
3.7 Multi-Threading (Learning)	09/01	09/03	100%
3.8 Multi-Threading (Application)	09/04	09/06	0%
3.9 Image Recognition Module 1 (Learning)	09/01	09/03	100%
3.10 Image Recognition Module 1 (Applicat...	09/04	09/06	0%
3.11 Image Recognition Module 2 (Applicat...	09/07	09/09	0%
3.12 Image Recognition Module 3 (Applicat...	09/10	09/12	0%
4 Android	**08/18/20**	**09/09/20**	**70%**
4.0 Requirement Elicitation	08/18	08/19	100%
4.1 Recap Knowledge Required	08/20	08/22	100%
4.2 Recap Knowledge Required 2	08/23	08/25	100%
4.3 Android App Prototyping	08/26	08/27	100%
4.4 Establish Bluetooth connectivity	08/28	08/29	100%
4.5 Develop Controller	08/30	09/01	100%
4.6 Display Status of Robot	09/02	09/03	100%
4.7 Develop GUI to Store Persistent String...	09/04	09/05	0%
4.8 Develop 2D GUI of Arena Manual	09/02	09/03	100%
4.9 Develop 2D GUI of Arena Automatic	09/04	09/06	0%
4.10 Develop GUI for Waypoint to Start po...	09/07	09/08	0%
4.11 Display Image ID on Arena Grid	09/09	09/09	0%
5 Algorithms	**08/18/20**	**09/09/20**	**75%**
5.0 Requirement Elicitation	08/18	08/19	100%
5.1 Research on Exploration Algorithms	08/20	08/21	100%
5.2 Develop Maze Simulator	08/22	08/24	100%
5.3 Exploration Algorithm Design	08/25	08/27	100%
5.4 Shortest Path Algorithm Design	08/28	08/30	100%
5.5 Implement Shortest Path Algorithm	08/31	09/02	100%
5.6 Test Algorithms	09/03	09/05	40%
5.7 Optimise Algorithms for Specified Cons...	09/06	09/07	0%
5.8 Establish Communication Protocols wit...	09/08	09/09	0%

(Figure 4- Project Schedule created with TeamGantt software)

APPENDIX A: KEY TERMS

The following table provides definitions for terms relevant to this document.

Term (A-Z)	Definition
Arduino	Arduino is an open-source electronics platform based on easy-to-use hardware and software.
Arduino Boards	It is a hardware device that can read inputs sensors and turn it into an output such as activating a motor or turning an LED in a controlled manner.
Arena	It refers to the container-like space of 2m length, 1.5m width, 0.15m height. It contains randomly generated obstacles that are seen as a maze within. The robot would have to navigate and move from a start zone to goal to compete for various leaderboard challenges
Robot	It refers to the assembled hardware device that will be used to navigate the arena.
Raspberry Pi / RPi	Raspberry Pi version 3 is a low cost, credit-card sized computer that plugs into a computer monitor and uses a standard keyboard and mouse. It is a capable little device that uses programming language such as python to read/communicate between different hardware devices.
Wi-Fi	Wi-Fi is the name of the wireless networking technology based on the IEEE 802.11 standard, commonly used for Internet access and local area networking.
RPM	Also known as Revolutions per Minute. It is a measurement to let the user know how many numbers of rotation of the DC (Direct Current) motor over one minute.