Project Deliverable H: Prototype III and Customer Feedback

GNG 1103 – Engineering Design

Group 5

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1.0 - Introduction

The purpose of this document is to present the third iteration of our prototype, integrating client and peer feedback from presentations. This prototype aims to refine key design elements such as the overall functionality of the product, while aiming for consistency through final structured testing. The final bill of materials (BOM) has been outlined. By validating the design through experimental evaluation using a meticulous table, this deliverable ensures that our final prototype aligns with the project's objectives and client requirements. A breakdown of all the steps will outline how our team planned to develop our third prototype, leading to how we overcome the listed challenges and feedback.

2.0 - Outline of Analysis

To begin with the development of the third prototype, it is important for our team to carefully digest all the feedback we have received over the course of the entire project. More importantly, we need to pay closer attention to how the most recent presentation went in the lecture time, as it is the scope of our entire project exposed to a much larger audience.

2.1 - Design Adjustments based on Feedback

The first thing we need to do is to collect the feedback we received from our presentations, in addition to the markings we made from testing our previous prototypes. It is crucial we process all of this in an effective way for us to better our product, and a table as the following can prove to be a sufficient demonstration.

Table 1 - Feedback and Corrections

Feedback / Issue	Correction(s)
Difficulty acquiring cards for pathing	Simplifying retrieval (see 4.0)
Inconsistency with detecting symbols	Adjusting exposure and size of symbols
Overall speed of RoboMaster S1	Corrected and explained in 4.0
Camera issues with lighting	Adjusting angle and exposure
Absence of outputting whether the RM is ready for symbol detection, and if it has been read	Implementing an additional colour and feedback pattern on chassis and gimbal, in correlation to the others

2.2 - Objectives

Now that we have processed all of what our third prototype can improve on from the previous criteria, we will transition towards creating objectives for this prototype. Our team has collectively agreed upon the following list to establish our goals, ambitions and what we want to pay more attention to as we near our final product.

- Perform further testing with symbol detection
- Deeply analyze the appropriate speed for comfortable assisted navigation
- Address and resolve the issues with camera settings
- Implement more feedback from the RoboMaster S1's current operation

3.0 - Development of Prototype 3

With everything being clearly outlined, we can use this information and move onto the development of our third and final prototype.

3.1 - Bill of Materials (BOM)

Here lies the purchases made that contributed towards the testing of the prototypes, and items we will use on design day. The receipts will be provided at an arranged time.

Table 2 - Bill of Materials (BOM)

Item name	Description	Quantity	Unit Cost	Cumulative Cost
Electrical Tape	For testing line tracking	2	$1.75	$3.50
Painter's Tape	Testing line tracking, but thicker width	1	$2.25	$2.25
Thicker Painter's Tape	Testing line tracking, but even thicker width	1	$2.50	$2.50
Construction Paper	Poster Board	1	$4.25	$4.25
Poster Board	Design day	2	$3.00	$6.00
Glue	Poster board	1	$2.50	$2.50
		8 items	**Total after Tax**	$23.73

3.2 - List of Equipment

Throughout the project, we have been consistently using the same devices and platform to work on the weekly deliverables, including the three prototypes. There were no expenses, but to clarify the equipment used, please read the following table.

Table 3 - Equipment Used

Item Name	Description	Cost (Purchased FOR this Project)	Source(s)?
Personal Laptop	To work on deliverables and program the prototypes	$0	N/A
DJI RoboMaster Software	For programming the RoboMaster S1	$0	https://www.dji.com/ca/support/product/robomaster-s1
RoboMaster Mobile App	For programming the RoboMaster S1 and to connect to the RM S1	$0	https://apps.apple.com/us/app/robomaster/id1449678340
Office 365	For documenting and collaborating on deliverables	$0	N/A

4.0 - Prototype III Testing

As outlined in table 1 above, our team has been working on correcting the issues and feedback given with the third prototype. To address each issue individually, starting with the cards for destination selection.

Over the course of the past few weeks, the issue of struggling to determine how the user will retrieve and return the cards for destination selection was addressed through re-designing the retrieval mechanism for enhanced efficiency and reliability. We decided it would be far simpler for users to pick up the card from a table which will be found above or next to the RoboMaster S1's starting position. To return the card, they will simply place the card back on the table, as the A.N.A. is designed to wait a few seconds before beginning the navigation process.

The camera settings were also adjusted by quickly experimenting with the different exposure settings found under the "Smart" tab, to fix issues with lighting and overall detection issue, which allowed for more consistent results in regard to pathing and symbol detection.

To optimize the overall speed of the RoboMaster S1, the machine was exhaustively tested and readjusted for hours, where I began with a code that would take the output of the PID error, and calculate a velocity to travel at based on how well the RoboMaster S1 was position on the current path. This proved to be a little difficult to follow, as sometimes the RM would be travelling quicker than a comfortable walking pace, with abrupt deacceleration. The solution was to then switch the velocity to be fixed at 1.0 m/s and should the RM have trouble detecting the current path, or go off course, deaccelerate to 0.5 m/s, while "troubleshooting". My approach to troubleshooting was to have the RM chassis and gimbal colour switch to yellow and slowly swivel to determine the correction.

Finally, a new feedback system was implemented to indicate when the RM is ready to scan a destination, and when it has been correctly identified. This was achieved by introducing another colour-coded feedback pattern on the gimbal and chassis to give concise and immediate status upon arrival of destination, in coordination with the existing system.

All relevant data can be found in the following tables.

Table 4 - Table Template for Recorded Data

Test ID	Test Objective (Why)	Description of Prototype used and of Basic Test Method (What)	Description of Results to be Recorded and how these results will be used (How)	Estimated Test duration and planned start date (When)	Figures to Demonstrate Results
1	Line-following accuracy	Testing the line following algorithm created to follow different colored paths	Recording speed variations, hesitations and deviations	10-15 minutes. Beginning of testing period	Figure 1
2	Line following accuracy with intersections / crowded paths	Testing the ability to differentiate paths from the desired one	Recording length of hesitation or buffer, any off track navigation it produces	15-30 minutes. After Test 1.	N/A
3	Symbol recognition for selecting paths	Showing the robomaster different symbols	Comparing reactions times and the	10-15 minutes. Can be performed	Figure 2 and 3

		on cards to check if it follows the correct path according to the assigned symbol	behaviour of detecting symbols that are not assigned	before or after Test 1 and 2	
4	Camera exposure settings	Exposure settings (low, medium high)	Experimenting with the levels of exposure to determine the best results	5-10 minutes EACH (3 settings). At most 45 minutes overall.	N/A
5	RM travel speed	Testing different chassis speeds.	Experimenting different velocities to enhance the comfort of the user, while making sure the RM delivers consistent pathing.	5 minutes at most with each speed. Overall, 60 minutes, to deliver a consistent basis.	N/A
6	Ready to detect symbol, and outputting the symbol has been detected	Implementing a suitable feedback system for a completed assisted navigation	Simply seeing what catches the eye as “destination complete” more than other colours and frequency of blinking	5-10 minutes.	Figure 3 and 4

Table 5 - Recorded Data for Prototype III

Test ID	Scale / System	Frequency	Results (Average)
1	Rating 1-10	25	8 (Increased over time with corrections)
2	Rating 1-10	10	9
3	Rating 1-10	10	7
4	Percentage of Accuracy	25	80%

5	Rating 1-10	30 (Lots of walking, lol)	8
6	Rating 1-10	10	9 (with the final selection being 10)

Images from Testing

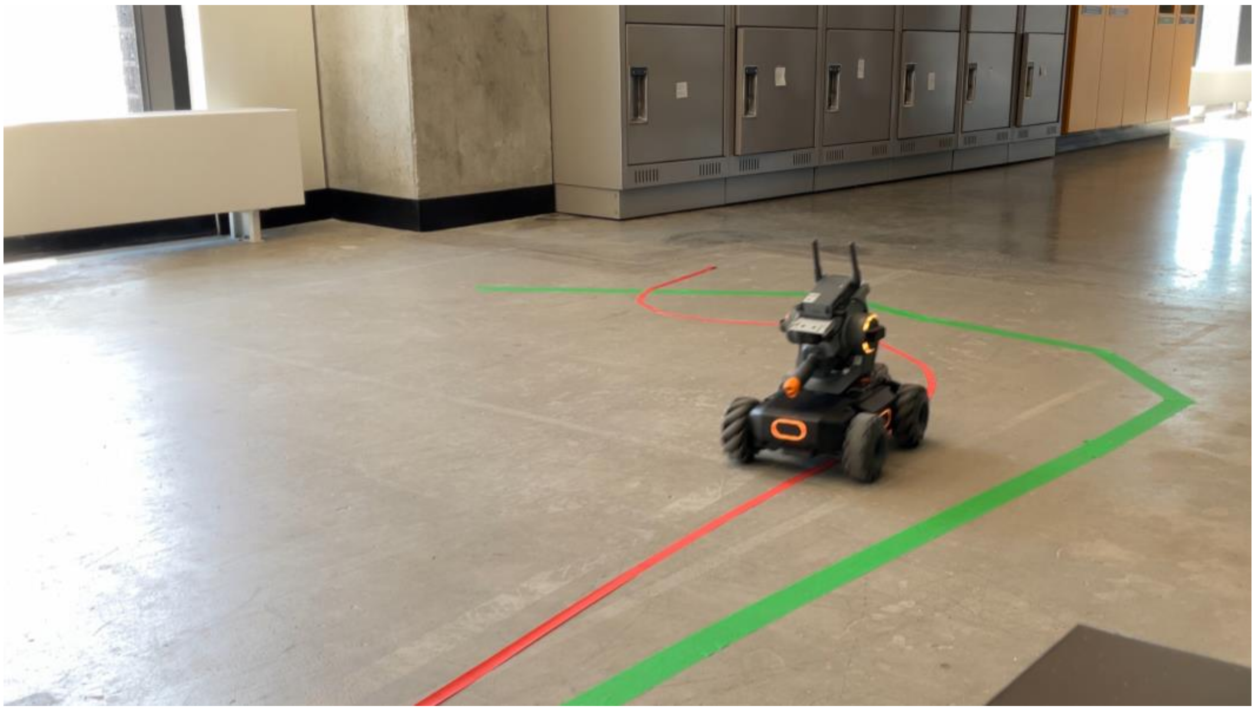

Figure 1 - Consistent Pathing

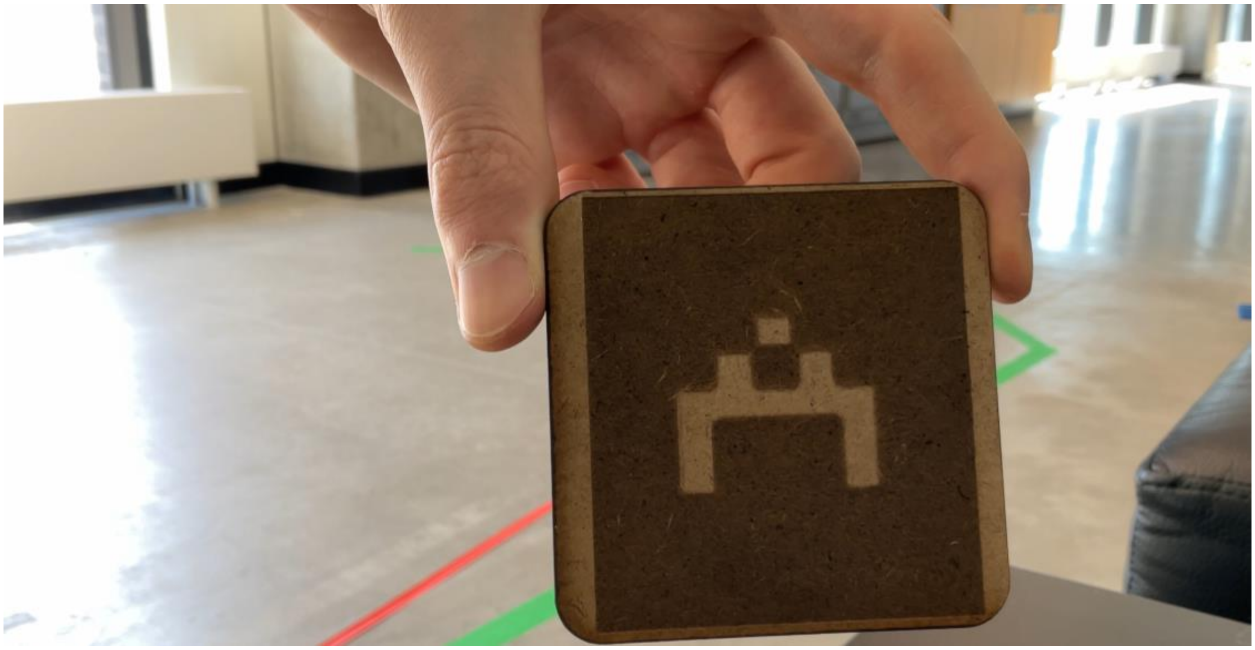

Figure 2 - Symbol Testing

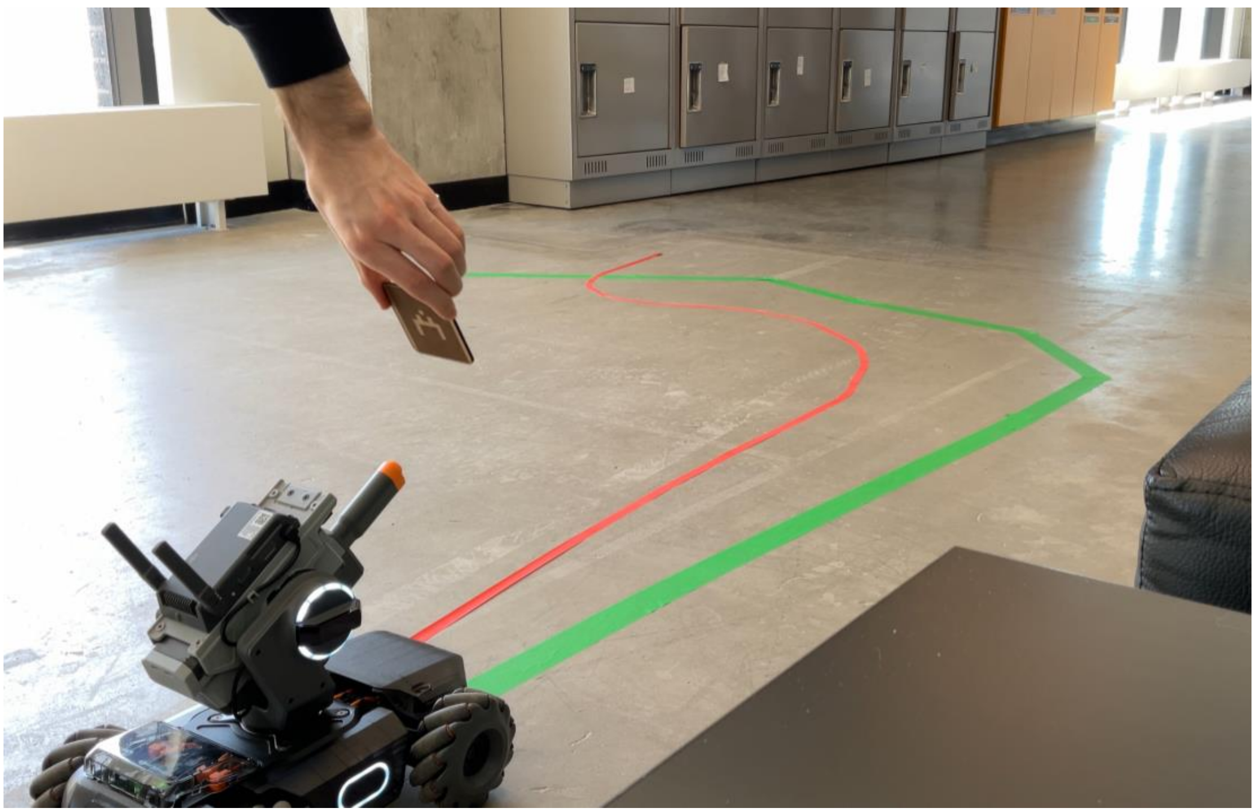

Figure 3 - Ready To Detect

Figure 4 - Completed Detection

(Gimbal blue light is on “scrolling” and gimbal pitch axis lowers.)

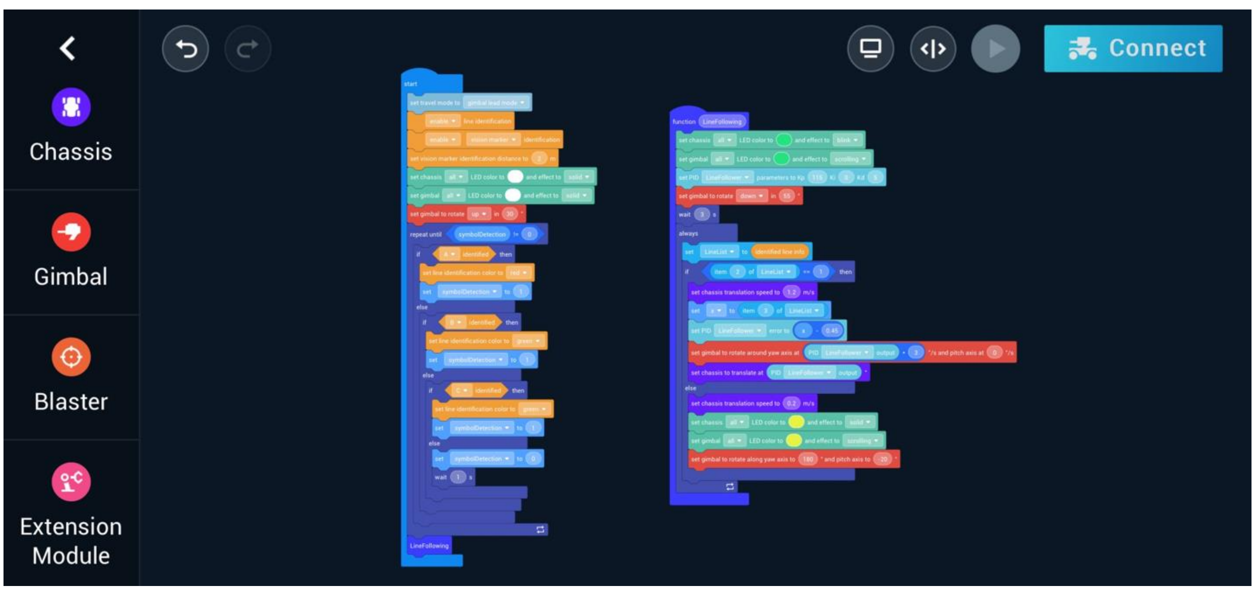

Figure 5 - Final code

Figures 6-8 - Sketches of the Symbols for Laser cutting

Figure 6 - Symbol A for Laser cutting

Figure 7 - Symbol B for Laser cutting

Figure 8 - Symbol C for Laser cutting

5.0 - Final Remarks and Conclusion

Now that the prototype testing has come to an end, and the design process is completed, it is important to summarize all the important feedback received from the final presentations, while addressing personal remarks as well.

5.1 - Final Remarks

In the final presentation, the key strengths noted were the overall performance of presenting, along with the implementation of the open feedback system to relay navigation status. The camera settings and symbol recognition upgrades were noted as key milestones since they greatly added to the reliability of A.N.A. in reading pathing markers.

Nevertheless, there are some concerns with over-simplification of the design. Whereas the initial version was too complex and therefore created problems with reliability and overload of processing, the new system, far more realistic for a first-year project as it was, may have oversimplified some aspects of the process. For instance, the purpose of the pathing could be further "investigated", and another related example would be to incorporate a feature for a more functional product, with targeted solutions.

5.2 - Conclusion

This project was a learning experience in the art of combining simplicity and complexity. Originally, the design tried to balance multiple variables dynamically, which resulted in a large variety of unnecessary complications, and an extended troubleshooting process. Realizing this problem with the help of feedback from the clients, the approach was redesigned into a simpler product that significantly enhanced reliability and user experience.

However, the outcome though successful, might have tipped too far in the direction of simplicity, sacrificing some possible flexibility. Subsequent iterations should aim for an equilibrium position, maintaining the key upgrades while reviving some adaptive functionalities to improve the system's flexibility without compromising its stability.