Prototype II

Team 2

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1. Introduction

Our next step in the design process is to continue our prototyping tests. In the last prototype, we collected data on if our design was meeting the required criteria regarding the illustration of ethical concerns. Now that we ensured our design was meeting the required criteria, we will move on to develop a prototype that tests the functionality of critical systems. The most important functional aspects of our design is the targeting and recognition capabilities of the RoboMaster. Without these features, our design would fail. We decided to write code to run simulations using the DJI app that demonstrates the needed targeting functions. Our tests will determine whether our design is feasible or not. This document will give a detailed breakdown of the prototyping process, displaying why we created the prototype, what will be tested, and when we will discontinue testing. The results will then be analyzed to determine if design adjustments need to be made or not and what our next steps will be in our design process.

2. Visual Processing function

Our current design uses the visual marker recognition function during gameplay. When considering how this will be implemented, we determined that this functional aspect needs to be tested as it is critical to how our end product will operate. In our previous prototype, we displayed that the RoboMaster will be scanning the cards, aiming, and firing. To properly execute this, our program must meet 3 target specifications. The RoboMaster must be able to scan the card in play, determine if the card is new or previously scanned, and aim at the card. This led to the development of a prototype that is able to test these 3 areas. Our testing criteria is as follows:

Design Requirement	Test method	How will results be recorded?	When will tests be discontinued?
Successful scan of visual marker	Develop code that implements this function. Run a simulation to determine if this function works properly or not.	Results will be recorded as pass/fail. This will be determined by the outcome of the simulation.Successful operation of the function would result in a pass.	Tests will be discontinued after multiple rounds of iteration. The stopping will be determined if the implemented function has proven to be

			successful or if the function has been deemed to be too complex to implement.
Program determines if visual marker is new or previously scanned	Develop code that stores the symbols of scanned cards and differentiates between new and previously scanned. Run a simulation that moves the FOV across multiple cards.	Results will be recorded as pass/fail. This will be determined by the outcome of the simulation.Successful operation of the function would result in a pass.	Tests will be discontinued after multiple rounds of iteration. The stopping will be determined if the implemented function has proven to be successful or if the function has been deemed to be too complex to implement.
Point and fire function implemented	Develop code that executes a point and fire function. Run simulations to determine if RoboMaster is able to execute this task.	Results will be recorded as pass/fail. This will be determined by the outcome of the simulation. Successful operation of the function would result in a pass.	Tests will be discontinued after multiple rounds of iteration. The stopping will be determined if the implemented function has proven to be successful or if the function has been deemed to be too complex to implement.

2.1 Justification

This prototype allows the group to test the ability of the robot to track and recognize the symbols throughout the experience. It will allow the group to understand the functionality and quality of the robots ability to scan and recognize symbols when symbols are lined up next to each other. This focused critical subsystem prototype will allow us to determine where there may be issues in the code in a critical system early on and be able to troubleshoot and iterate based on testing results.

2.2 High level overview

The visual parsing function is required to fit into an input output format, in order to be integrated into the structure of the game loop as a whole. This has been defined as following:

If face, card is within center area and they are is new

{

Point at card

Return (True)

}

Return (False)

2.3 Notes & Adjustments required to structure

- The block coding format does not support function returns. Instead, the boolean output of the function must be done through a globally defined variable.
- Card detection must be initialized in the main game loop.
- Location on screen is given as a float value from 0 to 1
- Cards can be distinguished (card index observed by robot), faces cannot be distinguished. In light of this, an adjustment is made to only scan cards, as the faces should be nearby anyways. This will greatly reduce the potential error rate.
- Detected card information is given in a built in list called “identified visual marker info”, a second list must be repeatedly updated to the contents of this in order to make use of it.

2.4 Implementation

In order to determine if the card is new and in the center of the robot's vision, two checks are applied to each currently visible card (curScanned). The first checks if the x-position of the card is between an upper and lower bound (minBound & maxBound). The second checks whether the card has been previously detected (and therefore “scanned”) by checking whether the card index exists in a list of previously scanned card indexes (prevScanned).

These checks must be applied to each currently visible card, to accomplish this, a loop is used at every check, iterating through elements of the list curScanned.

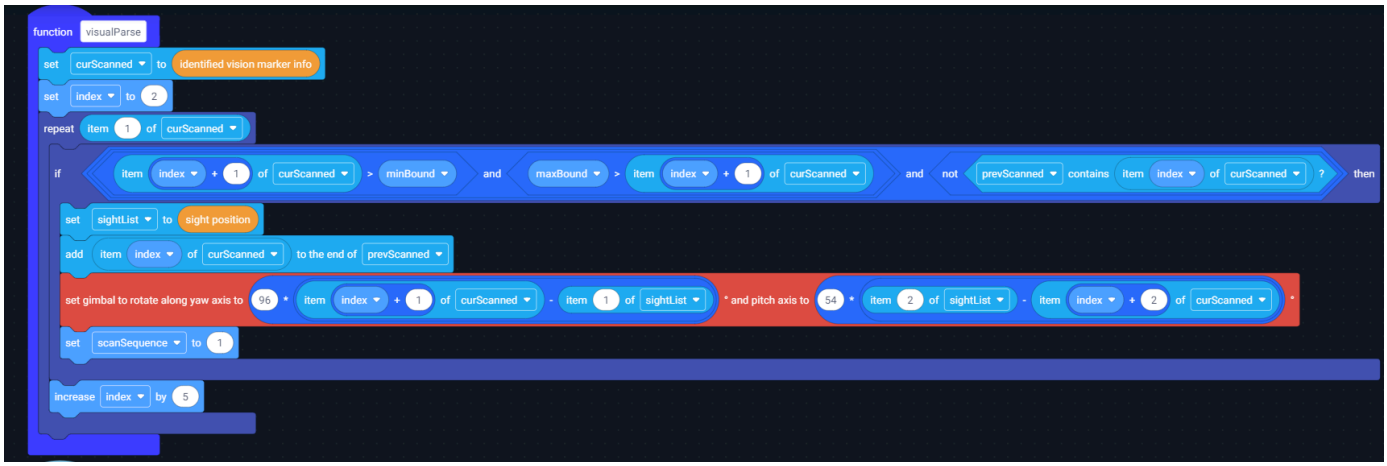
In order to point at the card, the difference from the current sight position (sightList) and the X,Y value of the card is obtained. A factor is applied to each corresponding to the field of view of the robomaster S1's camera. The turret gimbal is then set to point at this angle.

When a card is scanned, the global variable scanSequence is updated, which will later be referenced in the main game loop to initiate actions. This card index is then added to the list of previously scanned card indexes.

The function does not represent true modularization of the program, as several variables must be defined outside of the function.

The result of this implementation is shown below.

2.5 Prototype function



2.6 Analytical Model and Prototype Focus

This prototype development is designed to achieve the reliability of an analytical model that can support RoboMaster's visual processing and recognition systems. We model how accurately RoboMaster is able to identify and respond to game cards, a key subsystem necessary to successful gameplay. However, with this

analytical method, we not only can determine the system's effectiveness, but also will have the basis to verify feasibility and functionality in different instances.

2.6.1 Subsystem Analysis and System Integration

Game engagement is grounded on the visual processing capabilities, which is one subsystem important role in game engagement. This subsystem must be integrated into a game loop such that it maintains detection accuracy within a certain range around the game loop boundary while making continuous transitions between visual parsing and gameplay response. The assessment of the visual analysis rules was done by testing how it would respond under varied distances and angles for verification of the robot and accuracy in the real world.

2.6.2 Risk and Uncertainty Reduction

The suggestion is that this model analyzes robomaster’s ability to detect and respond to cards, that means identifying failure boundaries (such as delay in recognition or errors in multiple types of lighting). Early addressing of these issues reduces uncertainty, which decreases overall system final design risk and minimizes the occurrence of wrong user experience or functional failures. The analytical model is used to test detection limits, and then potentially lower the risk of mix up in live gameplay.

2.7 Communicating and collecting feedback on prototype ideas

Targeted user feedback has shaped each of the prototype iterations. In our study we presented the game scenarios and collected ratings on simplicity, clarity, and ethical message effectiveness to understand how the prototypes communicated with regard to ethical issues while offering a smooth interaction experience.

2.7.1 Feedback Highlights and System Adjustments

Prototype 1 Feedback was given saying that RoboMaster has to be improved in its visual parsing and the interaction. These adjustments were included in prototype 2, and this greatly improved user ratings of clarity and ease of understanding. The approach that we take in this work permits direct user feedback to shape each

of the subsystem adjustments, therefore improving design and functionality of the interactive capabilities of the RoboMaster.

2.8 Verification of Feasibility

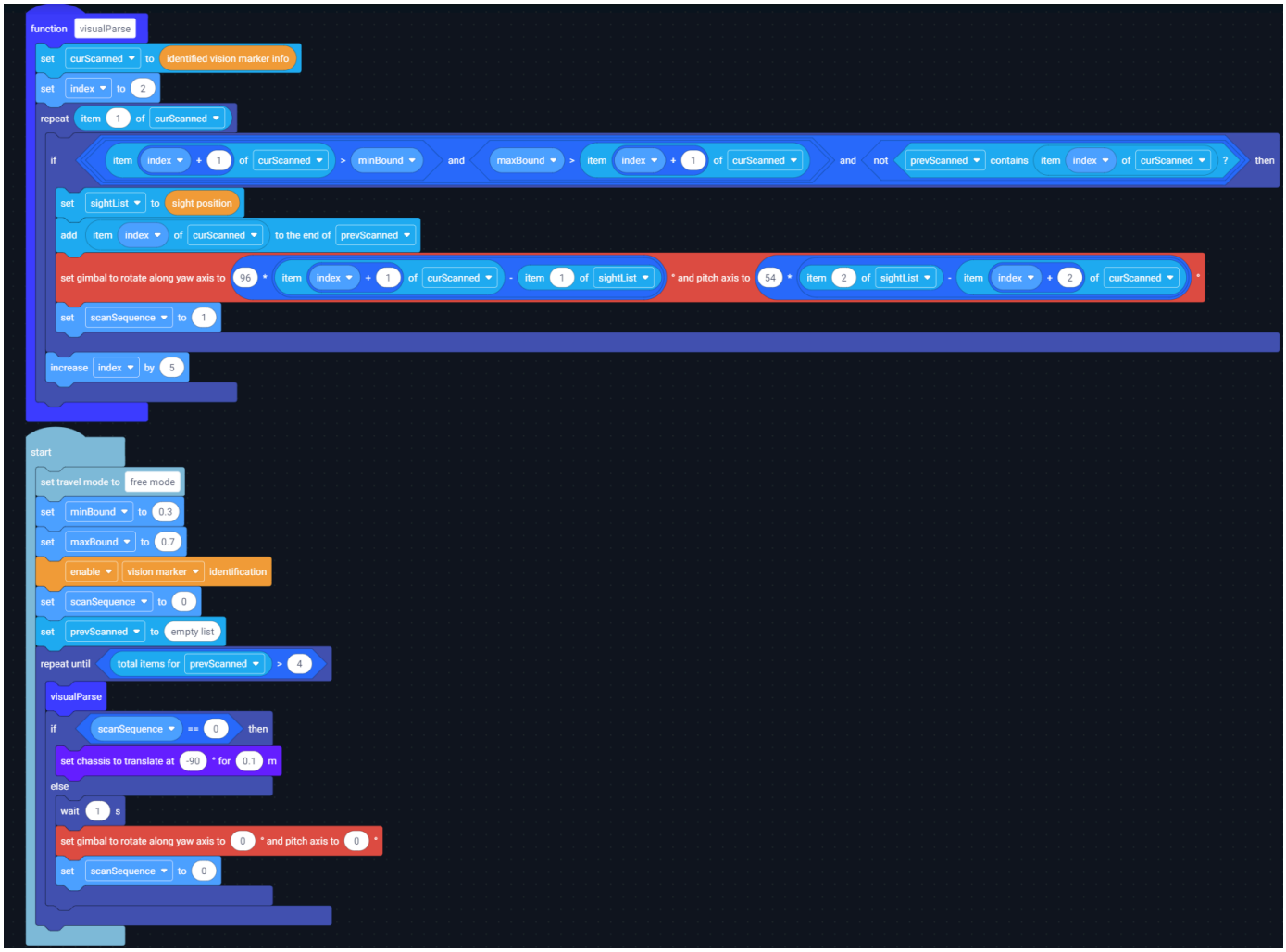
Therefore, we are in the process of our controlled tests under various conditions to confirm feasibility of RoboMaster's visual processing capability. Our feasibility aims to study that RoboMaster could achieve recognition accuracy within the acceptable range for most testing scenarios, and the visual parsing function could well assist the game play with little recalibration, based on detection speed, accuracy percentage, and consistency in gameplay conditions.

3. Testing

3.1 Test conditions 1

Testing was conducted in the DJI education hub virtual environment, which simulates the execution of code, along with the sensing and actions of the robot.

In order to verify the effectiveness of the prototype visual parsing function, an extension to the prototype was added, mimicking the scanning sequence in the game, as the robot moves along a line of players holding up cards. This program is shown below.



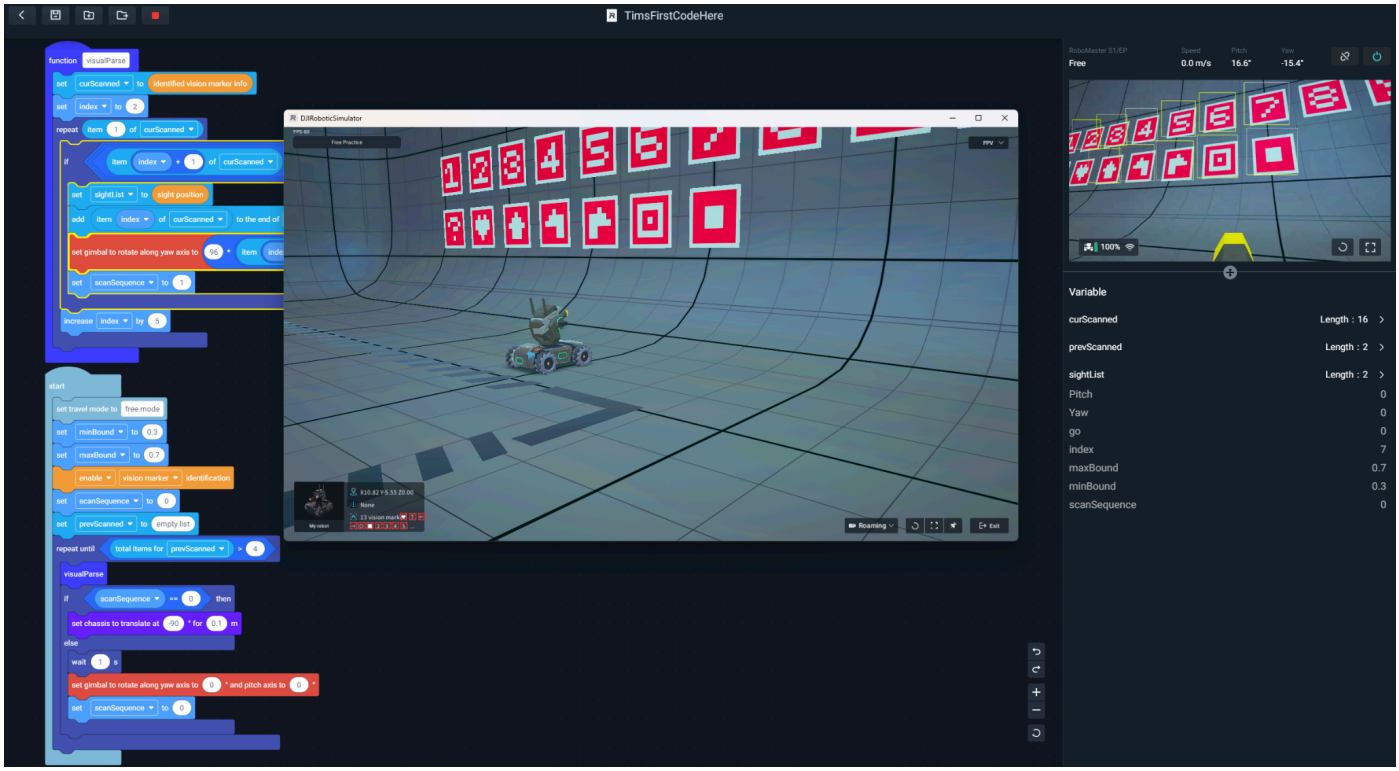
Several things should be noted.

- The minBound, maxBound variables definition, both differ by 0.5 by some constant. This is the acceptable range as to definitely catch a visual marker, but not include two.
- The initialization of visual marker detection, required for the visualParse function.
- The global variable scanSequence being set to the dormant value to initiate the program.
- The travel mode being set to “free mode” preventing errors when using turret yaw.

The robot was positioned in the virtual environment next to a row of visual markers, similar to the expected conditions of a row of players holding visual markers.

3.2 Results

The image below shows the robot moving through the test environment.



Final function test results:

Design Requirement	Test results
Successful scan of visual marker	Pass
Program determines if visual marker is new or previously scanned	Pass
Point and fire function implemented	Pass

3.3 Analysis

Several revisions were required during testing, and the process proved to be lengthy. Ultimately the completed function met all desired specifications. The function successfully identified new cards in the

center of the robot's vision, and pointed the gun towards them. The code runs sufficiently quickly and without errors. Variable values are within expected ranges and are consistent across tests. The testing was concluded as all specifications were met, and the testing is considered a success.

4. Previous Prototype & Feedback

In the previous prototype a goal was to gather feedback wherever and however possible in order to influence our prototype 2. We had gathered data from 10-15 people on simplicity, clarity of the ethical message, and comprehension in order to take that feedback and use it to influence this prototype. We had understood from the survey that while the game seemed fun and simplistic there wasn't much of an emphasis on a few ethical messages and the ethical messages that were presented weren't very clear to the users. By taking the feedback from our last prototype we are using it in order to make a heavier emphasis on our ethical messages in our future tests, and making sure this prototype is able to deliver a quality that we can use to improve our ethical messages. The feedback gained will be used to influence our future tests and priorities with this deliverable, and our next one.

5. Costs

This next section will outline the costs associated with this prototype as well as costs for our final prototype. Our client has given us a budget of $50 CAD.

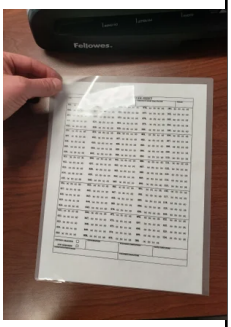
5.1 Prototype BOM

Part Name	Description	Quantity	Units	Part Image	Unit Cost (CAD)	Amount (CAD)	Supplier

DJI Education Hub	Software used to write code for RoboMaster S1	1	N/A		$0	$0	DJI
RoboMaster App	Software used to run simulations for RoboMaster S1.	1	N/A		$0	$0	DJI
Total						$0	

5.2 Final Prototype BOM

Part Name	Description	Quantity	Units	Part Image	Unit Cost (CAD)	Amount (CAD)	Supplier
3M™ Multi-Purpose	A role of Yellow tape. Used	1	Roll		$6.37	$7.30	Walmart

Duct Tape, 3920-YL, Yellow, 1.88 in x 20 yd	to mark boundaries .						
Colour, 1 sided printed page,8.5 x 11 inches	Custom colour printed page. Used for game cards.	30	Pages		$0.25	$7.50	University of Ottawa
Laminated paper, 8.5 x 11 inches	Laminated letter sized papers to create game cards.	15	Pages		$2	$30	Staples
Total						$44.80	

6. Prototype 3 Test Plan

Our next prototype will be a comprehensive, Hi-Fi, physical prototype. Future tests will be taken within the next week in order to test the functionality and effectiveness of our completed project. These will help us to further develop our design through analyzing the results of these tests, and to make sure our messages and other forms of communication are clear and comprehensible. Testing will stop after the defined stopping criterion is met, and iteration will follow if required specifications are not met.

Test #	Reason for Prototype	Evaluation Criteria	Metrics	Test Description	Analysis Method	Why?	Stopping Criteria
1	Robot Functionality	If the robot can complete its tasks	Pass/Fail	The robot will be tested in the software in order to judge whether the robot is able to complete its functions and subsystems when combined together	Careful consideration will be taken to stress tests and push the robot to its limits in order to judge how flexible the code is with a pass/fail.	This will help us in order to judge our progress and make sure we haven't missed any functionality	Once the robot has been able to prove it can function when all systems are combined, and after 2 rounds of testing
2	Ethical Message Clarity	User Comprehension	Survey	Peers will be asked to judge the state of the code and a storyboard in order to judge the clarity of the ethical message	There will be a rating from 1-5 for ethical clarity and further criteria added to a table on a document	This will allow the group to continue to represent our ethical concerns clearly	Once a large sample size of people have been able to judge the ethical message presented by the robot, and the survey is filled out completely
3	Robot timing	If the timing works with the code and users	Pass/Fail	A test will be executed in order to comprehend whether or not the timing works with human users but also matches up with other robot functionalities	The team will record time and present the timing to users and other group members. These will be judged to be too short, too long, or the proper amount of time	In order to make sure that the experience on design day isn't too long or short, and is able to be reasonably completed by any users	Once all bits of the timing have been tweaked, and are given a pass by all those who are asked. A fail would mean continued testing until it is all pass
4.	Robot readability	Will the robot register other symbols	Pass/Fail	The robot will be asked to read symbols that may be used in the experience in different lightings or shapes.	Different symbols will be presented in both the software and in person to judge in what conditions the robot is able to judge and recognise critical symbols	This will be done in order to see if the robot will be able to recognise the symbols in the experience come design day, but also to see if it may pick up on other symbols around design day	Once all game symbols in the final deliverable are presented and given a pass a final round of testing on any other symbols will be done to mitigate the code malfunctioning. This will continue until all necessary data is collected

5	User Perceptions	Can the users understand the robot	Survey	The robot will perform functions such as elimination or game instructions and the users must judge how much they understand the robots instructions	The robot will use its lighting, laser, and audio in order to present information to a group of users, where they will rate each prompt from 1-5 based on comprehension	The robot will be doing much of the presentation on design day, so it's important for us to make sure the users understand what the robot is doing and why.	Once the survey is filled out by a large group of users, the data will be collected and organized, then the test will be stopped

7. Conclusion

Testing and refining the visual processing capabilities of RoboMaster has been taken much further with Prototype II. Using feedback from Prototype I, the team was able to better enable the robot to locate and recognize visual symbols, a critical first step for the interactive game. The new prototype built upon RoboMaster's targeting and recognition capabilities by improving targeting and recognition to lower error rates and improve performance. The visual parsing function was evaluated on new symbols in a controlled virtual environment and was found to successfully identify new symbols and to point to the right location. System accuracy has improved through iterative prototyping based on user and team feedback; uncertainties have dissipated and the number of potentials for functional failures have been reduced. The design proved to be feasible through the ability of the modeling approach to have detection limits and reliable performances that pass through tests. Now that the team has the RoboMaster S1 in hand and can test more in person, we will test more with the RoboMaster S1 going forward and gather more user feedback to refine visual processing and overall gameplay experience. We are improving from our past products/prototypes that did not meet quality standards, ensuring they work well and are easy to use, and staying committed to ongoing improvement.

8. References

RoboMaster S1 - DJI. DJI Official. (n.d.). https://www.dji.com/ca/robomaster-s1

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