Project Deliverable F: Prototype I and Customer Feedback

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Abstract

This report presents the initial prototype and testing feedback for a RoboMaster S1-based project, developed to simulate the ethical concerns and challenges associated with autonomous weapons. The prototype aims to test key functionalities, including path-following, environmental interaction, adaptive targeting, and loss of control within an environment. The robot's behavior is designed to increase autonomy gradually, which will highlight the potential risks of misidentification and environmental degradation. The key tests assessed will be the robot's accuracy in pat detection, its response to unexpected obstacles, and the effectiveness of its targeting algorithm. The feedback from user testing identified areas of improvement, such as pacing the robot's autonomous behaviors and refining the simulation of environmental damage. This prototype serves as a foundation for subsequent development phases, with improvements focusing on refining accuracy, user interaction, and ethical implications in autonomous systems.

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1. Define the Purpose of the Prototype

Our prototype's primary objective is to test our chosen concept's feasibility, ensuring that key functionalities (subsystems) work as intended in a controlled environment. Specifically, this prototype aims to validate path detection and following, as well as simulation of loss of control, target accuracy, and targeting errors. Our tests with the RoboMaster S1's ability to detect and accurately follow a designated path are fundamental for our second prototype which will involve environmental interaction. The robot's capacity to deviate from the path in a controlled manner simulates a scenario where the robot behaves as though it is "losing control." This feature will illustrate progressive autonomy and unpredictability. Test scenarios where the robot "accidentally" targets unintended objects or individuals, reflecting potential misidentifications in high-stress or dynamic environments. These initial tests will all provide insights into the feasibility and reliability of these core functionalities, laying the groundwork for more complex ideas and introducing the need to change some functions to better suit the capabilities of the RobomasterS1.

The ethical concerns that are related to testing this prototype focus on reliability, safety, and public trust. The potential for the RoboMaster S1 to misidentify or mistakenly target objects highlights the importance of accuracy to prevent harm and build user confidence. Simulated "loss of control" scenarios raise questions about fail-safes, while path detection and following touch on privacy and surveillance ethics. Adaptive targeting introduces the risk of bias, emphasizing the need for careful calibration and transparency in the system's decision-making. Emphasizing these ethical concerns will help send the message about the dangers of autonomous robots/weapons to the player of the game.

The key components to evaluate the RoboMaster S1's functionality within a controlled environment:

- **OBJECTIVES**
  - Testing the robot's ability to detect and follow a pre-defined path while simulating controlled deviations to mimic loss of control.
  - Utilizing onboard sensors to detect obstacles, identify designated targets, and distinguish between intended and unintended objects. This includes evaluating the accuracy of the robot's sensors in real-time.
  - Implementing and testing adaptive targeting logic to prioritize specified targets while introducing controlled scenarios where the robot may "accidentally" target unintended objects.
  - Engaging with various obstacles to simulate real-world scenarios, such as avoiding or knocking over objects, which represents environmental degradation or unintended impacts.

Path Detection and Navigation Coding

- Timeline: Oct 28th - Nov 3rd
  - Activities: Develop and test the basic line-following code in a simulation environment, verifying the robot's ability to detect and stay on a designated path.

Controlled Line Deviation Coding and Testing

- Timeline: Oct 28th - Nov 3rd
  - Implement and test line deviation code to simulate controlled "loss of control" behavior, ensuring the robot can deviate from the path in specific scenarios.

Target Identification and Prioritization Coding

- Timeline: Oct 28th - Nov 3rd
  - Develop the target identification and prioritization algorithms. Test these in simulation to confirm the robot's ability to detect and engage specific targets.

Prioritization Malfunction Coding and Testing

- Timeline: Oct 28th - Nov 3rd
  - Test the behavior in a simulated environment, focusing on ensuring that these errors occur as designed.

Feedback and Refinement

- Timeline: Nov 3rd - Nov-10th
  - Conduct tests with potential users or team members, gather feedback and refine the prototype based on findings. Document insights for adjustments in the next prototype phase.

2. Focus on a Targeted Objective with Measurable Results

Destruction of Environment:

A smaller more manageable goal of the project is to show the destruction of a given environment. For this given project our group has designed a plan for the Robomaster S1 to gradually increase in autonomy. The game begins by showing the robot master patrolling a city completely fine and working nobly, however as the game progresses autonomy causes the robot to try for the pathway, and thus cause environmental destruction.

The concept of environmental degradation is one of the most important to our group as it was a massive highlight of our second client meeting thus it's essential we combine this with the presentation. Our group has already developed a methodology for how we can make the robot's pathway random and erratic instead of steady and precise. This can be done by changing the speed of the gamble and the body moving, when this happens we found that the simulation of the robot significantly strays from the main precise path. Thus the only testing that must be done is whether or not the robot has the capabilities to knock over the cups during this time.

Testing of this objective is extremely hard at the moment without the use of the actual robot, because we are unable to test whether the robot has the capabilities to knock a stack of cups over. Once the robot is physically in our group's possession we intend to test the robot and its capabilities when it comes to the destruction of buildings by keeping track of how many cups are knocked down each round, which configurations for stacking cups break more easily

3. Conduct a Simple Analysis of Critical Components

1. Sensors and Environmental Perception
- Functionality in a Stimulated Environment: The robot's sensors are critical for interpreting the environment, particularly when handling environmental degradation, such as moving around obstacles or detecting potential threats. In the simulation, these sensors must accurately detect and respond to obstacles. The accuracy of sensor feedback affects how effectively the Robomaster can engage or disengage with targets
- Challenges: A risk is that sensor data might not accurately reflect real-world interactions, particularly in complex environments or with physical obstacles. We may need to make some adjustments to ensure consistency in the robot's responses, mimicking real-life sensor limitations, such as environmental interference.
2. Adaptive Targeting Algorithm
- Key Function: The targeting algorithm is essential for adaptive prioritization, allowing for the robot to shift its focus based on the player's actions dynamically. For instance, the robot may prioritize the players based on whether they have the correct marker on them or not. The targets with the correct markers will be identified and targeted throughout the game, while those with a different marker may be spared.
- Analysis: This component involved a combination of threat assessment and decision-making algorithms. Testing in the simulation helps ensure that the algorithm accurately interprets player actions to prioritize effectively. Inconsistencies in how the algorithm interprets "aggression" vs. "evasion" could impact gameplay and require refinement to balance challenge and player experience.
3. Environmental Interaction and Control Loss
- Key Function: The robot's response to environmental changes – such as moving objects or degraded areas – aims to reflect realistic autonomous weapon behaviors. This functionality showcases the gradual loss of control, allowing players to experience how the robot may react unpredictably to environmental shifts.
- Challenges: The coding environment degradation and player interaction with objects as distractions or shields are critical. Testing should confirm the robot's ability to track and adjust based on these interactions, providing a realistic experience of partial control loss.

4. Document the Prototyping Test Plan, Analysis, and Results

Timeline and Activities:

Phase 1: Path Detection and Navigation Coding:

- Timeline: Oct 31st - Nov 5th
- Activities: Develop the code so that the Robomaster S1 follows a line and does not deviate from it in the simulation section of DJI.
- Results: Document observation, and take any important photos.
- Measurement of Success: Does the Robomaster follow the line accurately? Does the Robomaster always work successfully at this task or is there some times when it does not?

Phase 2: Line Deviation Coding and Testing:

- Timeline: Oct 31st - Nov 5th
- Activities: Implementing the process by which causes the robot to move in an erratic manner, deviating from the line, to show the gain in autonomy.
- Results: Document observation, and take any important photos.
- Measurement of Success: Is the erratic motion of the robot enough to knock over cups on the sides, to illustrate environmental degradation?

Phase 3: Target Identification and Prioritization:

- Timeline: Oct 31st - Nov 7th
- Activities: Develop the algorithms for target identification and prioritization. Validate the codes produced within the simulation software.
- Results: Document observation, and take any important photos.
- Measurement of Success: Does it work within the simulation? Given two targets, does it prioritize the desired target?

Phase 4: Implementation of Both aspects:

- Timeline: Nov 7th - Nov 9th
- Activities:
    - Verify within the simulation that the robot can identify targets while it is moving around the central police station.
    - Make sure that the gradual flow to the robot's increasing autonomy looks realistic within the simulation.
- Results: Document observation, and take any important photos.
- Measurement of Success: Does the implementation of the two aspects of the program work alongside each other?

Phase 5: Feedback and Refinement:

- Timeline: Nov 9th - 10th
- Activities:
    - From implementation in previous steps ask other users for their input on the project.
    - Ask TA, friends, acquaintances, and whoever has time to look over the simulation to see if the message is accurately being portrayed and furthermore if the prototype is worth pursuing or needs more work.
    - Collect input for whoever uses/observes the simulation
- Results: Document observation, and take any important photos.

5. Collect and Incorporate Client/User Feedback

Our prototype focuses on the robot slowly destroying the environment and getting out of human control. To gather feedback from potential users we showed them a short simulation of how it may look from an outsider's perspective as the robot slowly goes haywire and destroys the environment. We showed the robot going from correctly following the path to veering off and on the path, showing its increasing autonomy. Our focus groups were made up of classmates and people from around the residence, as these were similar to the demographics outlined by the Stop Killer Robots team. In general, our message was well received, but the environmental degradation happened a little bit too fast, so we need to slow it down to be more realistic.

6. Update Target Specifications, Detailed Design, and BOM

After testing, it was clear that the gimble must be pointing down in order to follow the line and that if the corners are too sharp, the robot loses track of the line altogether. This shows that the path must have heavily tapered corners. Moreover, with the gimble being focused on the ground as the robot follows the line, our characters must be shorter than the table card holders that we originally planned on using in order to be in view of the camera, 15 - 20 cm tall. To add some creativity and realism, we will be 3D printing our characters. They will each have a little slot on their head that will hold a symbol card for the robot to read.

In order to address the concerns relating to environmental damage overload, we will be using the same cup system, just less of them. Fewer cups will be used for the existing buildings.

The main challenge with this project is keeping the game as simple as possible, while still being engaging for the player and showing the ethical concerns with autonomous weapon systems. With this goal in mind, we are constantly trying to simplify the game to prioritize functionality.

7. Outline a Test Plan for the Next Prototype

Assessing Typical Objectives:

Currently the biggest uncertainty with prototyping is whether or not the robomaster will be able to detect sensors. Due to there being a lack of access to the physical robot we are working with simulations, therefore its hard to determine whether the prototype will actually work as well in the simulation as it does with the actual robot. Thus, it's essential for us as a group to determine multiple solutions for getting the robot to do a specific thing. Furthermore we require testing of different methodologies, symbols to detect, and a variety of other aspects to determine the best solution. Testing of prototypes can be done by virtually anyone and their assessment of the program should be noted.

Furthermore in the testing and prototyping phase it is essential we assume some level of failure and it is important to acknowledge this aspect and how one may solve it. Moreover, as there is a time requirement it is important that while testing we acknowledge how long the game is taking.

As prototypes are produced there is a large possibility that they may become more complex to add more elements, it is important to survey users after testing and determine whether the point of the presentation is understood, and whether the user felt overwhelmed. As much as it seems beneficial to

make the game more complex it is important that the complexity of the presentation doesn't hinder the theme. Ultimately by the end of the presentation it is realistic that that prototype should be tested around ten times by a variety of individuals.

Stopping Criteria:

Ultimately the stopping criteria is when the prototype accurately supports and exemplifies our reasoning of why autonomous robots are so bad. To understand whether these ideas are understood by the users, it is important to survey any user testing the prototype to gain and understand whether or not they understand the issues being addressed. Furthermore, as there are concerns about the physical program working with the actual robot and with symbol detection, if these two aspects are successful then the prototype itself can be deemed successful in terms of programming aspects.

Fidelity:

With the ideas and aspects covered I believe there is a very high fidelity with this project, in terms of programming aspects. In terms of whether the central messages will shine through, that is something that must be addressed as more physical prototyping is produced. However, as a group, we are confident that there is fidelity in users understanding the central message as this is what has been assessed by classmates in lab 7.