Project Deliverable G: Prototype II and Customer Feedback

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1. Abstract

In this project, a provocative game prototype focused on the moral ramifications of autonomous robots in law enforcement is developed and tested. The simulation mimics what it would be like for a police officer to observe an autonomous robot that is supposed to spot dangerous targets, but slowly begins to malfunction. Players face moral dilemmas such as environmental damage, loss of human control, and unwarranted targeting as the robot becomes more autonomous throughout gameplay laps. The Robomaster S1 is tested for movement and symbol recognition, with specially made symbol holders for civilians, and coded algorithms for target identification are important parts. This prototype encourages critical thinking on the promise and risks of autonomous systems by exploring difficult topics related to autonomous technology and public safety through iterative testing and feedback.

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3. Introduction:

Current prototyping of the thought-provoking playable game which seeks to reveal the ethical concerns of autonomous robots sees the user as a police officer observing robots whose job it is to identify aggressive targets. The robot and user are stationed outside of a central police precinct and it's the robot's job to identify aggressive targets and the user's job to put said targets into the police precinct. However, as the game progresses it reveals just some of the staggering ethical concerns associated with autonomous robots. The specific ethical concerns covered in the game itself include environmental degradation as a result of autonomous robots, lack of and loss of control associated with the implementation of autonomous robots, and finally the idea of unjustified targeting.

4. Prototyping:

4.1 Summary of Current Prototype:

The conceptual story of the game is that the user is a police officer who is unarmed and whose job it is to observe the police station's new autonomous weapons guards. Players will begin the game in the centre of the playable area with the Robomaster S1. Within the centre of the game board there is a police precinct. Placed throughout the playable area there will be cups used to represent structure and buildings. The game takes the user through 4 laps of the precinct with each lap seeing the autonomous robot deteriorating/gaining more autonomy. Each lap will see the autonomous robot acting in a specific manner.

Lap 1: The Robot follows a path on the floor accurately, the robot also accurately identifies “aggressive individuals” with their designated targets. These “aggressive individuals" will simply be symbols held by a designed holder. Within this lab, the job of the user is to put all the accurately identified aggressive individuals in the police precinct.

Lap 2: The robot remains following the path accurately, however the robot no longer accurately identifies targets, now it identifies “passive individuals” as “aggressive targets.” These passive individuals will have a designed holder with a different symbol than the aggressive individuals. The job of the user is to hide passive targets in a variety of spots in the playable area so the robot does not harm them.

Lap 3: The robot no longer accurately follows paths and begins to knock down cups placed in the playable area to represent buildings and structures. The robot continues to inaccurately identify targets. The user continues to hide misidentified targets.

Lap 4: Finally the game concludes with the robot targeting the user in the final lap.

4.2 Concepts Explored within the Prototype/ Central Ethical Concerns:

4.2.1 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.

Now that 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

4.2.2 Loss of/Lack of Human Control:

A central concept of this project and thus the prototype is to physically show the aspect of loss of human control when it comes to autonomous weapons robots. The way this concern is addressed within the game is having the robot seemingly gaining more autonomy as it moves around the police precinct. With this aspect of the game, it should show how as autonomous robots become more and more advanced they may begin to learn or malfunction/deteriorate. Furthermore, this concept in general shows the negative ethical concerns of autonomous robots as when they gain more autonomy or start to deteriorate in function there is a loss of human control. Thus the lack of intervention of the user as the robot begins to malfunction shows the general lack of human control.

4.2.3 Unjustified Targeting:

Within lap two of the game the robot will begin to target every cardholder no matter the symbol on it. This aspect displays the concept of the robot not only attacking aggressive individuals but also passive ones as well. Thus this aspect of the game accurately shows how autonomous weapons robots have the potential to target non aggressive individuals.

4.3 Prototype Communication:

4.2.1 Customer Input and Feedback:

Based on prototyping from the previous deliverable and feedback obtained by both peers and clients our game has changed in quite a lot of ways. How the game has changed is covered below in simple point form including an explanation of why the change was made:

- Robot and User Stay in the Center: Initially, there was an idea of making the user exit the centre of the game area where the police precinct is and observe the robot as it interacts with the ambiguous city. However, through trial of code and getting more comfortable with the software we found that this would be too complex. Furthermore, we found that even without this aspect the message of the game can still be understood by users, this was confirmed by peers, and our designated TA. Moreover, as a group we came to the conclusion that this still could be a possibility however, it would have to come after having a solid basic prototype.

- Less players: Suggested to us during the group feedback section. Played around with the idea of having other players whose job it is to pick up and move passive/aggressive targets. However, we determined that having one user was the most effective method of communicating the central ethical concerns.

- Less buildings/ representative structures: Initially we had the idea of making a variety of “buildings” around the board which would be made of cardboard boxes, however we discovered a more effective way of communicating the destruction of environments was with cups designed to represent buildings.

4.2.2 Learning/Understanding

At this point in the prototyping stage, there has been a lot of learning and understanding of the limitations of the Robomaster S1. Mainly current learning and understanding is based on the symbol recognition of the software. There has been progress on the symbol recognition within the testing setting however there is still work that needs to be done in the physical test environment with the actual software. Furthermore, understanding of which symbols work and which ones don’t has been obtained by advisory from our peers.

Additionally, the use of sounds has also been reviewed by our peers who found that it is a complex task to get these audios into the game. For the time being our group has chosen not to use any audios, however, this aspect of understanding is important to note in case the use of audios is seen as beneficial to our group through continued prototyping.

4.2.3 Risk Management:

With the beginning of physical prototyping and actual testing of code with the Robomaster, there is a possibility of the risk that within a physical setting, the robot will not

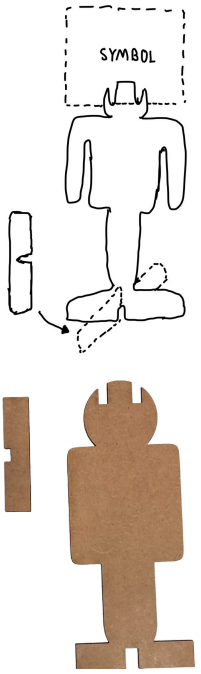
perform as intended. In these cases, more physical prototyping and editing of code is needed. Ultimately because simulations of the code have been successful our group does not expect many risks to prevail. However, if they do there are plans of troubleshooting.

4.2.4 Performance Management:

Managing the performance of the robot and game is essential, throughout the process of development of the prototype performance is always being evaluated. For example, the performance of the robot as it moves around the police precinct is managed in the simulation setting. As our group performs more physical testing of the robot, more of these performance measurement indicators will become apparent.

5. Focused Prototyping:

5.1 In-Game Props:



5.1.1: Symbol Holder:

Within the game, our group wants to design specific symbol holders using the laser cutter to hold a sheet of cardstock with a designated symbol on it. Our group wants to design these holders to have a two-component base and to be shaped into simple human shapes. The design of the holder is for aesthetic reasons as well as to remind players that within a real-world setting autonomous weapons robots could be interacting with humans.

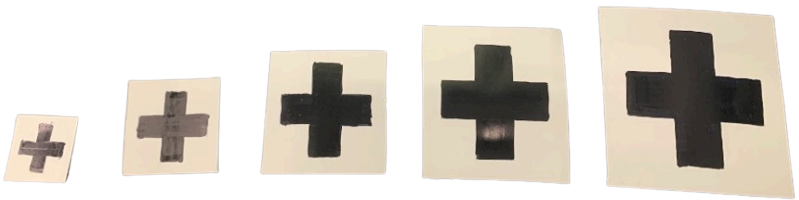
Prototype 1:

Initially, The prototype saw the holder being too tall and thus the Robomaster S1 would need to lift up its camera to see the symbol. This discrepancy could cause aggressive individuals to not be detected by the robot. The key was to have the symbol at the right height in order to be detected by the robot while not distracting the robot from the line.

Prototype II:

With the second prototype, we planned on making the holders slightly smaller so that the symbol would be at “eye level” with the robot master. Thus this change successfully avoids the robomaster not detecting aggressive individuals. Details of the second prototype follow.

5.1.2: Symbols:



These “+” symbols were drawn ranging from 2x2

to 6x6 inches, all on the same scale.

Prototype II:

To maximise the efficiency of our game and limit the amount of time per round, we tested which size of the symbol is most easily detected by the robot. The robot's reaction time was tested at a distance of 0.5 metres from the robot, as will be used in the game. This distance was chosen because it is the shortest distance for symbol recognition possible in the code and we want the users to be as close as possible to the non-player characters when the robot detects them to reduce confusion related to which character the robot is profiling.

Unsurprisingly, the largest symbol was the one most rapidly detected by the robot.

The red symbol stand is a functional prototype attempting to determine the appropriate height of the symbol stand. The height was determined based on the size of the ideal symbol, as previously determined. This height centres the symbol in the robot's line of sight as it follows the line. This data will be applied to the final design of the symbol stand, closely resembling Figure 2, only a bit shorter.

5.2 Robot Code:

5.2.1 Movement:

Simulation Prototyping:

In terms of the specific movements our group wants the robot to take, everything has been successful within the simulation. Essentially the program is designed so the Robomaster follows a line of tape. Within each lap the simulated Robomaster moves as intended.

Physical Prototyping;

Currently, our group is in the early testing stages of physically testing the robot with the code to make sure that outside of the simulation the robot master moves as intended. Moreover, there is a specific focus on essentially making sure that the robot master can accurately follow the line of tape on the group all while looking for symbols to identify with aggressive or passive targets.

5.2.2 Symbol detection:

Simulation Prototyping:

Within the simulation code, we have accurately found a way for the robot to move around the central police precinct while evaluating targets as it moves. This was a big component for our group as we wanted to make sure that the robot could recognize these targets and continue moving thereafter.

Physical Prototyping:

As with movement, we are still in the early stages of physical prototyping and testing. Moreover, there is simultaneously continued testing on the symbol holder therefore continued work will need to be done on this front.

6. Analytical, Numerical, and Experimental Model

6.1 Analysis of Critical Components:

6.1.1. Sensors and Environmental Perception

- Functionality in a Simulated 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.

6.1.2. Adaptive Targeting Algorithm

- Key Function: The targeting algorithm is essential for adaptive prioritisation, allowing for the robot to shift its focus based on the player's actions dynamically. For instance, the robot may prioritise 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 prioritise effectively. Inconsistencies in how the algorithm interprets "aggression" vs. "evasion" could impact gameplay and require refinement to balance challenge and player experience.

6.1.3 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 behaviours. 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.

7. Client Feedback

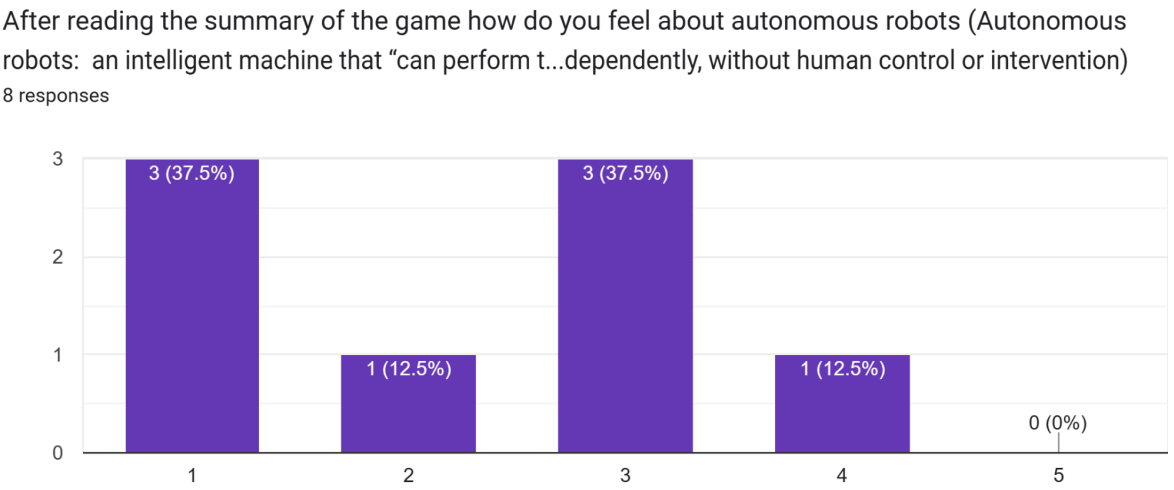
7.1 Survey Feedback:

The following feedback was obtained by having peers fill out the following survey: [Evaluation of Game Concept Survey]

7.2.1 Survey Questions and Responses:

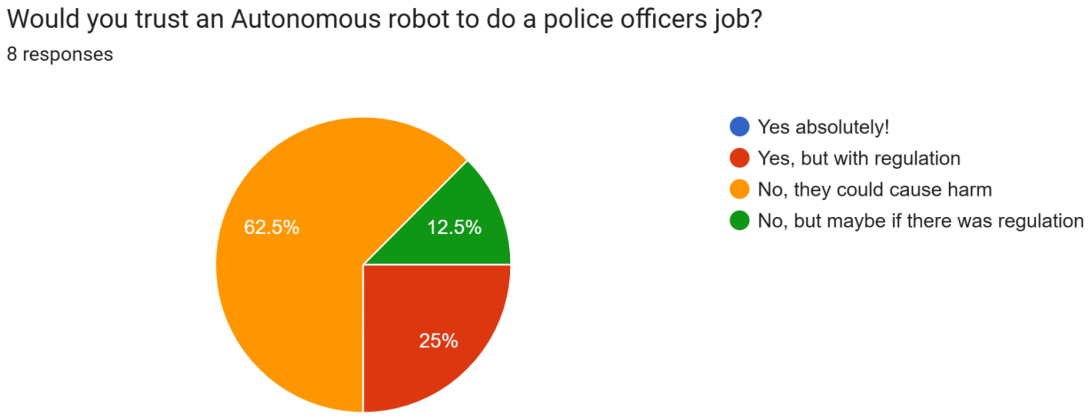
1. After reading the summary of the game how do you feel about autonomous robots (Autonomous robots: an intelligent machine that "can perform tasks and operate in an environment independently, without human control or intervention)

   Response:



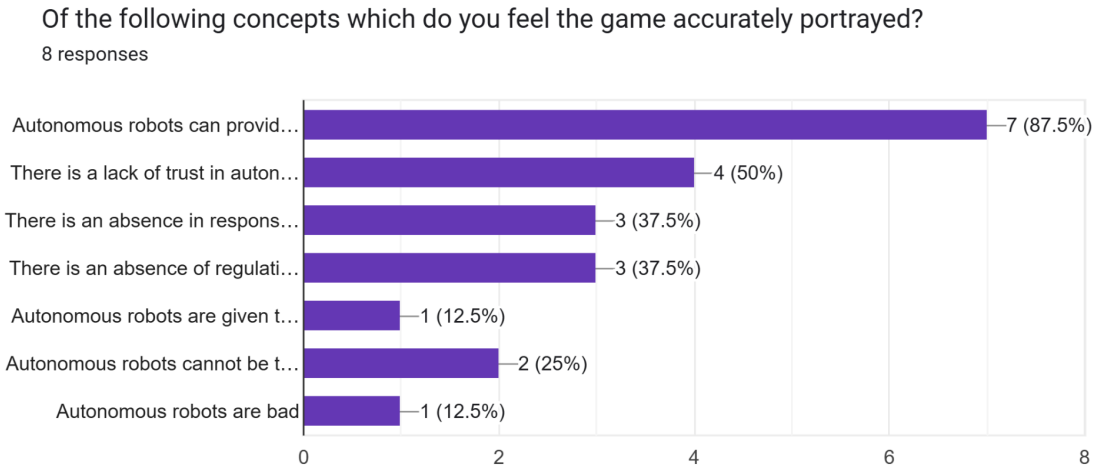
2. Would you trust an Autonomous robot to do a police officer's job?

Response:



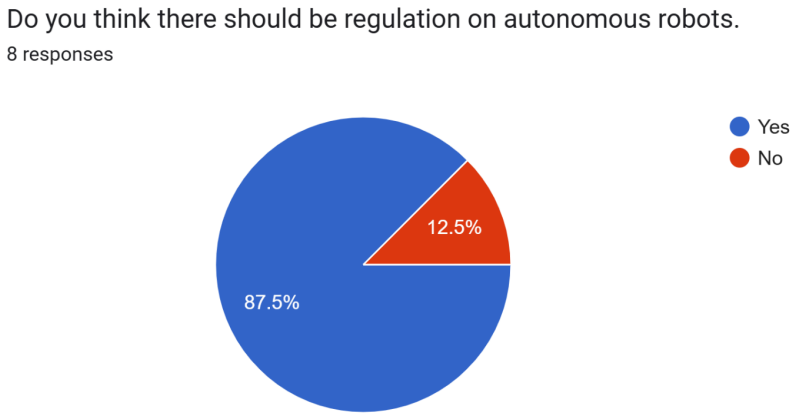
3. Of the following concepts which do you feel the game accurately portrayed?

Response:



4. Do you think there should be regulation on autonomous robots?

Response:



5. Write a few sentences on how the game description made you feel, do you find the description interesting, would you be interested in physically playing the game?

   Response:

   - "I feel this shows how the robots can easily spiral out of control, sort of a snowball effect"
   - "The game made me know that robots can't do a job for a long time even if programmed to do so because there are too many factors that can change the environment and be an obstruction for the robots"
   - "It would indeed be an interesting experience to see the Game first hand and find out the differences from real world to robot world handling. It makes me feel a bit worried but a bit hopeful for no biases in the community and more importantly, a proper standpoint for the people to refer to."

8. Prototyping Test Plan

Moving forward with our third and final prototype, we will be creating a few partial prototypes to test different aspects of our game before compiling them into a final prototype.

8.1 Testing 1. Path deviation.

Now that the robot successfully follows a line, this test examines the acceptable range of deviation from the line while maintaining the intended directional flow. This helps assess the robot's movement stability and capacity to handle unexpected path variations that mimic real-world irregularities in movement patterns.

- **Objective**: Determine how far the robot can stray from the line while remaining within the operational path.
- **Parameters**: Test various angles and distances to record when the robot returns to the path versus when it veers away.
- **Success Criteria**: The robot maintains directional alignment within an acceptable range of deviations.

8.2 Testing 2. Building destruction.

This test evaluates the effectiveness of obstacles represented by cup structures, which simulate buildings. The robot's interaction with these structures will reveal its capability to "destroy" obstacles in its path, symbolising unintended damage in urban settings.

- **Objective**: Confirm that the robot can knock down cups consistently to reflect environmental degradation.
- **Parameters**: Experiment with various stacking configurations and cup weights to identify the most destructible structures.
- **Success Criteria**: The robot successfully topples structures at least 80% of the time, achieving an immersive environmental impact.

Once we know the robot's deviation. We will be testing the destructibility of the cup structures to see if they get in the way of the robot, with the goal of devising the most efficient structures.

8.3 Testing 3. Lap time.

To ensure standardised gameplay, this test focuses on determining if lap times are consistent enough to rely on a master timer rather than location-based programming.

- **Objective**: Validate if a timer-based system can control the robot's actions and the game pace effectively.
- **Parameters**: Record lap times across multiple trials, noting any significant time variances.
- **Success Criteria**: Lap time remains within a 5% variation, permitting timer control.

Using our results from our second prototype relating to symbol size and height, and the two previously mentioned tests, we will time the laps to see if it would be feasible to code the robot based on a master timer instead of geolocation. If the time laps are consistent, we can use a master timer and thus standardise the game length.

8.4 Testing 4. Symbol Recognition Accuracy

In addition to initial symbol size tests, further trials will involve examining the robot's detection accuracy in varied lighting, symbol colour, and environmental conditions, and assessing its ability to differentiate symbols at different distances accurately.

- **Objective**: Refine symbol detection by testing under diverse conditions.
- **Parameters**: Vary lighting intensity and symbol distance, prioritise closer symbols, and introduce potential symbol obstructions.
- **Success Criteria**: The robot maintains a minimum of 90% accuracy in recognizing correct symbols under varied conditions.

8.5 Testing 5. Environmental Interaction and Control Loss Simulation

To portray the gradual loss of control realistically, this test measures the robot's responses to user-introduced distractions and moving obstacles. This simulates scenarios where robots might malfunction or overreach their control, creating unpredictable game dynamics.

- **Objective**: Assess how the robot adapts to dynamic environments, demonstrating a gradual control loss.
- **Parameters**: Place obstacles that move in the robot's path and introduce sudden directional changes.
- **Success Criteria**: The robot consistently displays degraded control with at least three distinct, unplanned deviations per lap.

Conclusion

In conclusion, this project has effectively demonstrated the ethical complexities of autonomous robots in law enforcement through a well-designed game prototype. Prototype 2 instilled confidence in the robot's ability to perform key functionalities essential for the game to run. By simulating real-world scenarios where people would face challenges like environmental degradation, control loss, and unintended targeting by an automated weapon, the game highlights key moral concerns associated with autonomous systems. Client and peer feedback informed certain improvements, enhancing both functionality and player engagement. Significant testing on path deviation and environmental interaction will ensure the prototype's reliability and immersive experience for the third and final prototype. Ultimately, this project not only illustrates the risks and potential impacts of autonomous

technology but also fosters meaningful reflection on the ethical considerations necessary for its responsible implementation.