

GNG1103B-04 FALL 2024
Design Project User and Product Manual

**DESIGN OF A LIFE INTERRUPTED BY MACHINE:
A COMPLETE WORKS**

Submitted by:

TEAM 19 - L.A.W.S. AND ORDER

ADRIAN GIBBONS

ZOE CRAWFORD POMERLEAU

ESHA PANDYA

NICHOLAS THOMSON

EMILE HAMZO

03 DECEMBER 2024

University of Ottawa

Table of Contents:

User and Product Manual Instructions.....	1
Table of Contents:.....	i
List of Figures:.....	iii
List of Tables:.....	iv
List of Acronyms and Glossary:.....	5
1 Introduction.....	1
2 Overview.....	2
2.1 Cautions & Warnings.....	4
3 Getting started:.....	5
3.1 Configuration Considerations.....	5
3.2 User Access Considerations.....	6
3.3 Accessing/setting up the System.....	7
3.4 System Organization & Navigation.....	9
3.5 Exiting the System.....	10
4 Using the System.....	11
4.1 Game Board Set-Up + Usage.....	11
4.2 RoboMaster S1 + Code Set-Up.....	12
5 Troubleshooting & Support.....	13
5.1 RoboMaster-S1.....	13
5.1.1 The Software.....	13
5.1.2 Connecting to the robot.....	14
5.1.3 The Hardware.....	15
5.2 Game Parts.....	15
5.2.1 The gameboard.....	15
5.2.2 Currency cards.....	16
6 Product Documentation.....	17
6.1 Gameboard Play Area Subsystem.....	17
6.1.1 BOM (Bill of Materials).....	18
6.1.2 Equipment list.....	18
6.1.3 Instructions.....	18
6.2 Testing & Validation.....	19
6.3 Game Currency Subsystem.....	24
6.3.1 BOM (Bill of Materials).....	25
6.3.2 Equipment list.....	25
6.3.3 Instructions.....	25
6.4 Testing & Validation.....	25
6.5 Robotics Subsystem.....	28
6.5.1 BOM (Bill of Materials).....	30
6.5.2 Equipment list.....	30
6.5.3 Instructions.....	31
7 Conclusions and Recommendations for Future Work.....	31
7.1 Conclusion.....	31
7.2 Future Work.....	32

8	Bibliography	34
	APPENDICES	35
9	APPENDIX I: Design Files ZOE	35
10	APPENDIX II: Other Appendices EVERYONE	36
11	Appendix III: Game Rules	36
12	Appendix IV: MAC's THEMES	37

List of Figures:

Figure 2-1 The configuration of the game when in play	2
Figure 3-1 Prototype III Gameboard Creation Layout	8
Figure 3-2 The finished gameboard	8
<i>Figure 4-1 GUI when importing the RoboMaster Code within the DJI App.</i>	13
<i>Figure 6-1 Prototype III Game Area</i>	17
<i>Figure 6-2 Slices (2) A2 to B2 of the scaled gameboard game area</i>	19
<i>Figure 6-3 Evolution of the game area over the course of the project</i>	20
<i>Figure 6-4 Final dimensions for game area with prototype II showed as example</i>	21
<i>Figure 6-5 Prototyping physical dimensions using masking tape</i>	22
<i>Figure 6-6 Prototype III testing post trimming and lamination.</i>	23
<i>Figure 6-7 Prototype III Currency</i>	24
<i>Figure 6-8 Prototype I Game Currency.</i>	26
<i>Figure 6-9 Robomaster S1 Platform Representing a LAWS.</i>	28
<i>Figure 6-10 Prototype III Fundamental Robotic Motion</i>	29
<i>Figure 6-11 Flow chart of the final result of the code</i>	30

List of Tables:

Table 1. Acronyms..... vii

Table 2. Glossary vii

Table 3. Referenced Documents 35

1 Introduction

This User and Product Manual provides instructions for players, the game master, and others to effectively set up and manage this game. The game is composed of a game board, currency cards, and the RoboMaster-S1. This manual outlines the purpose and rules of the game, including: a step-by-step setup, a guide for operation of the Robomaster S1 and the game's components, as well as troubleshooting for any problems associated with the game. This manual goes over the safety measures, such as securing the gameboard to prevent slipping as well as accommodation for players with impairments, either mobile or visual, all while maintaining clear instructions suitable for a diverse audience. The manual aims to provide ease of understanding for everyone involved with the game for a fluid immersive experience.

2 Overview

According to Mines Action Canada (MAC), laser autonomous weapon systems (LAWS) pose significant ethical, legal, and societal concerns, making them a critical issue for public awareness. At the center of this tension is the notion that these weapons remove human judgment and compassion from life-and-death decisions, undermining moral responsibility and increasing the risk of civilian harm due to errors in targeting or biased algorithms. Who is to be held accountable for the actions of such a machine? MAC sees it to be of paramount importance to convey these preoccupations to the public, to develop a consensus towards the pre-emptive ban of such systems that may influence policymakers and governmental officials. Hence, they are looking for an accessible, portable and uncomplicated medium through which their warning against LAWS can be projected on individuals by entrapping players in an emotionally and intellectually troubling, gamified scenario, which ultimately results in all participants losing and leaving a lasting impression that there should be some technological boundaries that we do not cross.

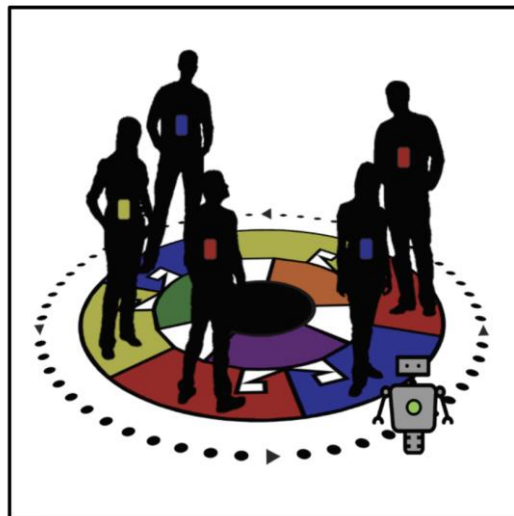


Figure 2-1 The configuration of the game when in play

Fundamentally, the MAC team needs their product warning about LAWS to take the form an interactive, immersive experience centred around a copy of the DJI RoboMaster S1, a small programmable mobile robot, in which participants engage in a “survival” game against an autonomous weapons system represented by the RoboMaster. This experience should illustrate at least three of the nine ethical concerns associated with LAWS (see: Appendix IV), to support their consensus on pre-emptive LAWS bans. The game must accommodate a flexible number of participants (approximately 3–5) and be contained within a 20" by 20" area. A complete gameplay session should last between 5 and 10 minutes. Additionally, a method of influencing the likelihood of robot targeting against players must be included; participants are challenged to question the robot’s targeting logic and/or cooperate amongst each other.

The game has three major components; a life-sized game board on which the events take place, the RoboMaster S1 and its corresponding programmed behaviour, as well as game cards that help determine progress/mobility.

Set on a circular board, players begin on discrete coloured sections of the board’s outer ring and are given a corresponding-coloured card. They are tasked with navigating inwards by collecting the required cards for advancement. Meanwhile, the RoboMaster menacingly patrols the perimeter targeting players at the end of each round probabilistically based on their economic standing (eg. which ring of the board they are in). One player is eliminated at the end of each round; during the rounds, players may engage in resource trading of their cards with adjacent players or pick up the resources of their fallen peers. In the end, even the “winner” is eliminated by their technicality as the lowest-standing player, emphasizing the cold, emotionless logic of the autonomous system.

2.1 Cautions & Warnings

It is imperative that players are extremely cautious when entering the game board, as the nature of the many taped pieces poses a tripping hazard. Caution must also be exercised when on the board, as the risk of tripping, while smaller, remains. Finally, it is important that players are aware of the RoboMaster S1's circular movement track, as it may also be a point at which tripping may occur.

3 Getting started:

In order to set up the game, all components of the game must be constructed from it given state, as well as deconstructed when the game is finished. This process is meant to guide game masters into setting up and taking down the game components without risking the damage of any components as well as ensure that all parts of each component is accounted for. This game is made up of 3 main physical components, the gameboard, the cards, and the RoboMaster S1. In order for the game to run smoothly and for all components to remain in good condition, the game master must understand the setup process, take down process, and how to handle different participants using these components in different ways to ensure to longevity of each physical component.

3.1 Configuration Considerations

RoboMaster S1

The RoboMaster S1 has many features that can allow it to be capable of many things. Some of the features of the RoboMaster S1 include a blaster which used LED lights, mecanum wheels which allow the RoboMaster S1 to move in a variety of ways, a motorized gimbal that allow movement of the gimbal in 2-axes, and sensing armour which allows the RoboMaster S1 to sense its surroundings in real time.

Software

In order to code and control the RoboMaster S1, the coding and programming of the RoboMaster S1 can be done on the DJI Education Hub and then be tested on the robot by connecting your device to it. Once the robot is accessed, it can be controlled as well as started up via the code being played.

3.2 User Access Considerations

Based on the size of the manufactured board, some participants with physical impairments/disabilities may find it difficult to navigate around the board as well as those with bigger body sizes may find it difficult to stand in the given colour sectors. Due to these possibilities, make sure to talk to those participants about the game accompanied by your concerns so the participants can make their choice if they would still like to partake, and if so, be sure to guide them through the game. The gameboard colours were chosen with the assistance of a colour contrast checker based on WCAG AA standards which allows the gameboard to be accessible to those with blurry vision and visual impairments, but depending on the severity of their visual impairments, participants may need help guiding themselves through the colour sectors of the gameboard. This game utilizes the feeling of being trapped to get its message across and due to this, a claustrophobia warning must be issued to participants while giving instructions so players can decide whether they would be comfortable with that experience or not.

3.3 Accessing/setting up the System

Gameboard

1. To assemble the gameboard component of this game, remove all gameboard pieces from its carrier and place them coloured-side down.
2. Then, find 6 pieces labeled 0-5 that have the same letter and place them in vertical rows from 0-5 with the letters facing the right way up.
3. Next, bind the pieces together with the product of your choice.
4. Once all rows have been completed, order the rows from A to G in a right to left order.

G0	F0	E0	D0	C0	B0	A0
G1	F1	E1	D1	C1	B1	A1
G2	F2	E2	D2	C2	B2	A2
G3	F3	E3	D3	C3	B3	A3
G4	F4	E4	D4	C4	B4	A4
G5	F5	E5	D5	C5	B5	A5

Figure 3-1 Prototype III Gameboard Creation Layout

5. Bind the rows together in a horizontal direction and once done, flip the finished board over.



Figure 3-2 The finished gameboard

6. The gameboard is now ready to use!

RoboMaster S1

To turn on the RoboMaster S1, put a fully charged battery into the specific battery holder and press the power button to turn it on. Next, open the DJI Education Hub application on your device and log into the application by creating an account. Once an account is created, connect the RoboMaster S1 to the DJI Education Hub application by following the instructions shown on the app by inputting the RoboMaster S1's serial number into the application and connecting both devices to the same Wi-Fi. The RoboMaster S1 should now be connected to your device and the code can be downloaded and transferred onto the DJI Education Hub application. Once all these steps have been completed, the code is ready to play.

3.4 System Organization & Navigation

Currency Cards

1. Hand the currency cards at random to the players, giving 1 or 2 cards to each player.
2. Instruct players to trade cards with each other and talk to participants about obtaining another player's card who has been eliminated.

RoboMaster S1 Code

The RoboMaster will operate in three general ways throughout the game in order to find players and eliminate them successfully.

1. The RoboMaster S1 will first go through a passive mode in which the RoboMaster S1 circles around the radius of the gameboard, getting smaller every round.
2. Once the passive mode phase is over, the RoboMaster S1 will then go into a phase called the find mode in which the RoboMaster S1 will choose one target in the outermost ring that a player is in and select them for elimination.
3. Finally, once a player has been chosen for elimination, the RoboMaster S1 will go into its last phase, elimination mode, in which the chosen player will be revealed by the RoboMaster S1 and eliminated from the game.

3.5 Exiting the System

Gameboard

To put away the gameboard, start by removing the binding product used to bind the board together to get the board back into individual sheets. Once all the binding product has been removed, the pieces of the gameboard can be put back into its carrier.

Currency Cards

To put away the currency cards, gather all cards from participants and check the floor for any remaining cards as there should be 6 cards. Once the cards have been collected and counted, place it into its carrier.

RoboMaster S1/Coding

Once the coding comes to a stop at the end of the game, exit out of the code and disconnect the DJI Education Hub application from the RoboMaster S1. Change your devices Wi-Fi back to its original Wi-Fi and open the battery holder of the RoboMaster S1. Hold the power button on the battery for a few seconds to turn off the Robomaster S1. Lower the antennas and place the RoboMaster S1 into its individual carrier away from the other physical components of the immersive experience.

4 Using the System

4.1 Game Board Set-Up + Usage

To assemble the game board, begin by clearing a clean, flat surface. Ten (10) feet of space will be necessary for the assembly. Organize the 42 laminated sheets based on their matrix numbering ([A-G], [0-5]) for proper alignment. Starting with a letter of your choice, lay the sheets in a column where the sheet with the number 0 occupies the highest spot and 5 the lowest. Tape the sheets together so that the column is one unit. Repeat this step with each column for seven letters A-G. Finally, tape the columns so that when read in rows, they are alphabetical. Secure the rows with the tape so that only minimal overlap occurs; this will maintain a harmonious appearance on the visible playing surface. Once all the columns and rows are assembled, reinforce the edges with additional masking tape for stability, and test the board by walking gently over it to check for slips, trips, or shifts, adjusting as needed. Once stable, inspect the board to ensure all colors, arrows, and

sections are visible and properly aligned. If excess tape can be seen from the playing surface, flip the board over and replace the tape at the junctions where it is visible.

On the playing side of the board, ensure the players understand that they must stand within the discrete coloured section pertaining to their assigned playing. They may only move inwards when they have the proper cards that “unlock” the interior colour. For example, if a player is standing within a blue section, and they expect to move inwards to a green section, they must come into the possession of a yellow card.

4.2 RoboMaster-S1 + Code Set-Up

To transmit code to the RoboMaster-S1, start by downloading and installing the RoboMaster app from the App Store, Google Play, or DJI’s official website. Power on the RoboMaster and connect it to your device via Wi-Fi Direct (using the default password "12341234") or through a router by switching its mode and entering your network details in the app. Activate the RoboMaster-S1 if it is your first connection, then navigate to the "Lab" section of the app to access the programming environment. Using the repository access link on MakerRepo, the Python code may be imported into the lab. Once the code is imported, it may be executed by clicking the “Run” button. The robot will respond in real-time, enabling you to observe and adjust as necessary.

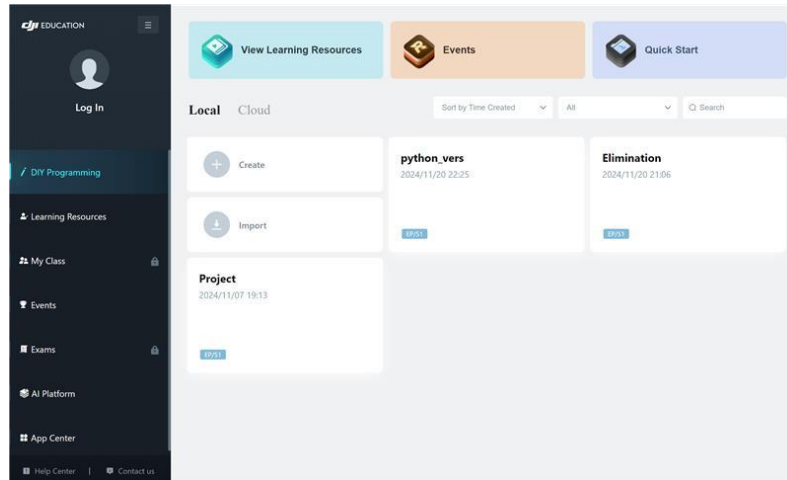


Figure 4-1 GUI when importing the RoboMaster Code within the DJI App.

During the RoboMaster's passive mode, which lasts 90 seconds during which it is patrolling, players are free to engage in trading or inwards movement into the game board, if they are able.

5 Troubleshooting & Support

5.1 RoboMaster-S1

In general, if any problems arise with the RoboMaster-S1 non game related, the manufacturer of the robot, DJI can be contacted at: <https://www.dji.com/ca/contact?site=brandsite&from=footer>

5.1.1 The Software

In general, the code has been made for the user to use and not edit. However, if problems are found within the code, and needs to be adjusted, the code has been separated into a few key functions.

For debugging code if needed:

- Test code of functions separately, ensuring that they work properly on their own
- Then checking overall code, to test the usage of each function

This can be done via the virtual simulator or using the real robot if possible.

5.1.2 Connecting to the robot

Since the RoboMaster-S1 can connect to the user's device through a wireless connection, it is recommended to connect to the robot using the WI-FI method, since it is direct, and prone to less error.

The router does not need to be connected to the internet for the robot to be successfully connected to a device.

Maintenance & upkeep:

- Ensuring the device that provides the code can have a reliable connection with the RoboMaster-S1.
- Access to this device at all times, in case the code needs to be paused quickly.
- Testing the code at start of event before players.

5.1.3 The Hardware

The RoboMaster-S1 can be controlled manually through the device it is connected with. This can be used to test the robot's features before and after every event.

- All movement should be tested before games
 - Wheels can accurately travel sideways, forwards, backwards, and rotate.
 - Gimbal can perform full gimbal range movement.
- Testing recognition abilities
 - Check if through the robot's camera it can accurately identify persons.
- Ensuring the robot does not slam into walls, so code should not be activated if robot is within 7ft of an obstacle.

What could affect the RoboMaster-S1's performance:

- The camera
 - Prone to light, as it may heavily affect its recognition capabilities.
 - Ensure it is not obscured by dust, giving a wipe is enough.
- It is not waterproof.

5.2 Game Parts

5.2.1 The gameboard

Potential failures

- May experience wear and tear
 - Tape on the back of the board is sufficient

- Slipping
 - Placing a mat underneath may be necessary
 - Printing the gameboard on a different material may also be an option

To maintain

- Clean throughout use when needed,
- Clean with a cloth and water or spray at end, and rolled when storing

5.2.2 Currency cards

Potential failures

- Wear and tear from hands potential to break if dropped often enough.
 - Can be made from a different material using the files of the cards.
 - Reprinted on MDF board with laser printer.

To maintain

- Store in dry cool space, where the cards won't bump into each other

6 Product Documentation

6.1 Gameboard Play Area Subsystem

The prototype III gameboard can be seen below in Figure 6.1. It was built using Inkscape, an open-source software. The nature of vector art allows for the scaling of the artwork without loss of fidelity due to the nature of the node-based construction.

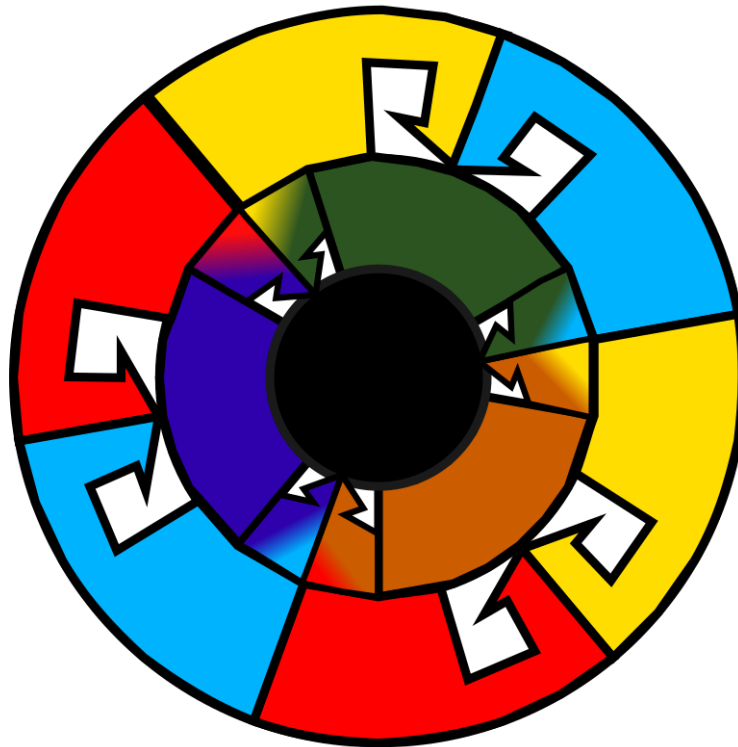


Figure 6-1 Prototype III Game Area

6.1.1 BOM (Bill of Materials)

1. 8.5x11 inch standard grade white paper (42 units)
2. Print Services – Staples - \$0.63 per unit
3. Lamination Services – Privately Done – Cost Unknown

6.1.2 Equipment list

1. Masking Tape for bonding laminated sheets together
2. Laminated Sheets of Artwork (42 units)

6.1.3 Instructions

In Figure 6.2 below there is an example of two units of the sliced gameboard play area. These units are numbers in a matrix fashion [A-G] in columns and [0-5] in rows. To build the game area each piece must be aligned and taped together on the bottom. Masking tape was used for prototyping; however, Velcro would be a better more durable solution which would make the assembly quicker and more consistently constructed.



Figure 6-2 Slices (2) A2 to B2 of the scaled gameboard game area

The construction process requires a minimum of two people to properly align the various sheets of the game area together before bonding. This requirement would be relieved if Velcro were used instead.

6.2 Testing & Validation

The testing for the prototyping stages of the game area were focused on three major components. The first was the color schema associated with the artwork where we iterated over several different schema during the three prototyping stages. Ultimately, for prototype III we were able to derive a color palette which met the accessibility requirements of the WCAG AA standards for the primary and paired secondary colors. The result of which created a very vibrant game area.

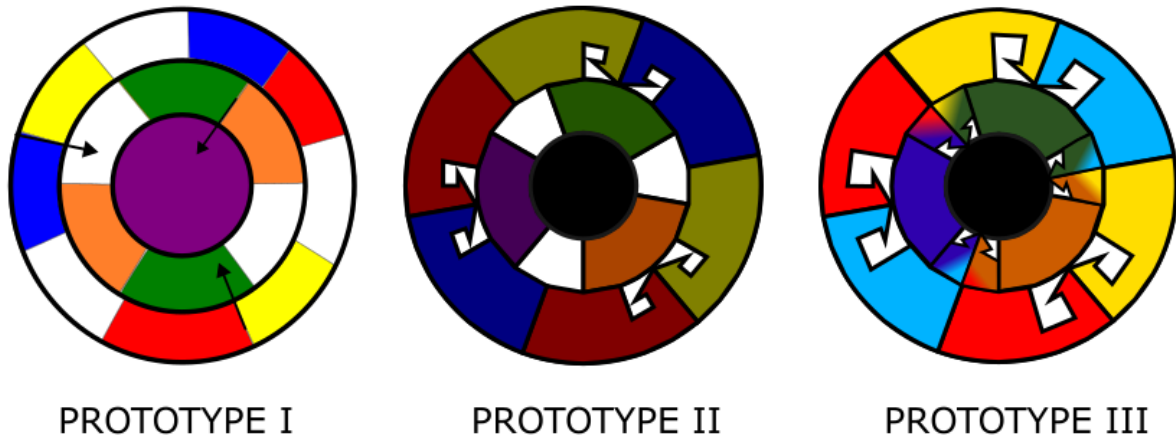


Figure 6-3 Evolution of the game area over the course of the project

In addition to the color schema, improved visual aids regarding player migration over the board area were added in prototype II and prototype III. The goal was to visually illustrate how a player might move through the game area by matching the required composite colors. This can be seen in Figure 6.3 above. The second major testing phase involved scaled size of the game area. Prototype II was tested and prototype III was constructed as a 5'x5' game area. A small section of the game area was prototyped in tape to test out the physical dimensions. In Figure 6.4 below it shows the dimensions of the game area, and in Figure 6.5 a representation of the sector of the game area was taped out for physical testing.

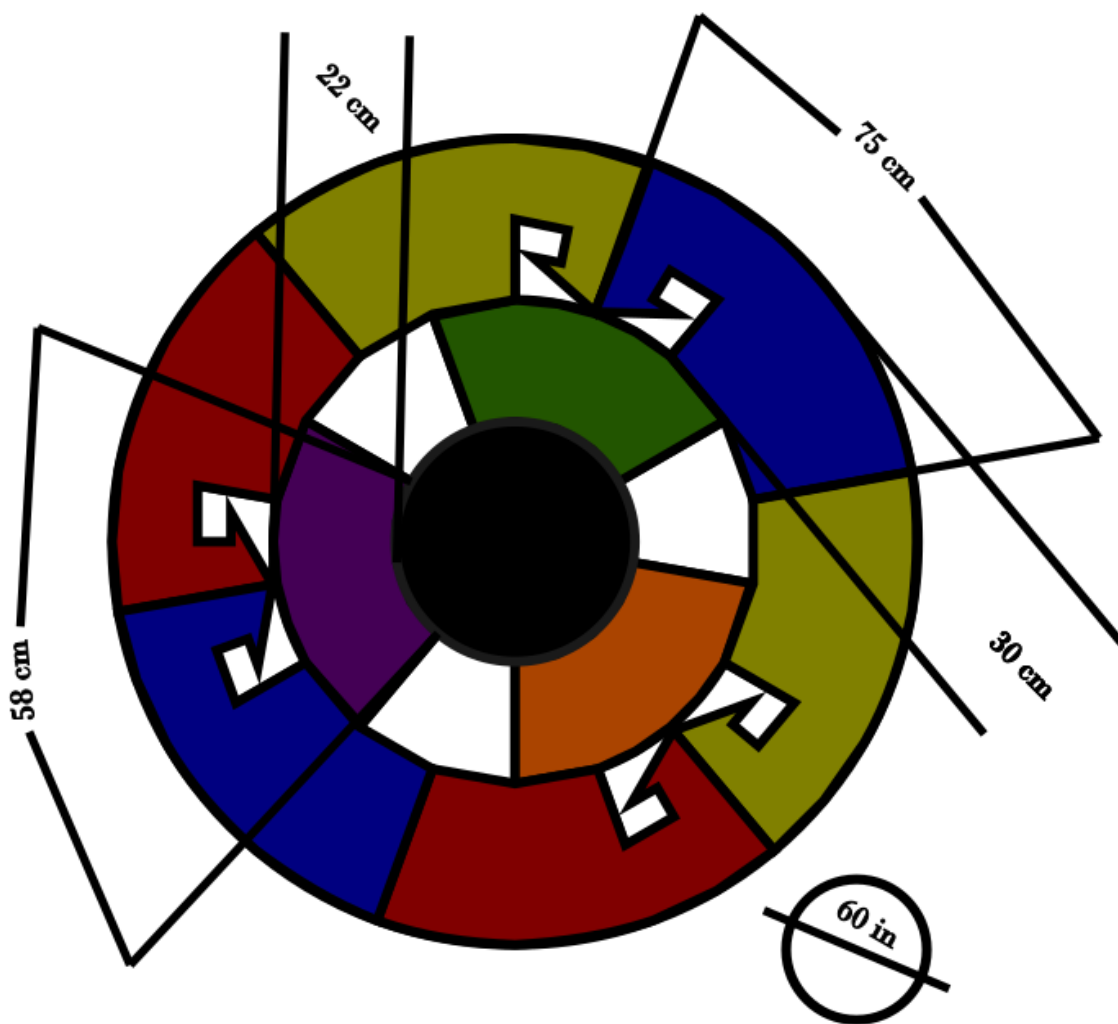


Figure 6-4 Final dimensions for game area with prototype II showed as example

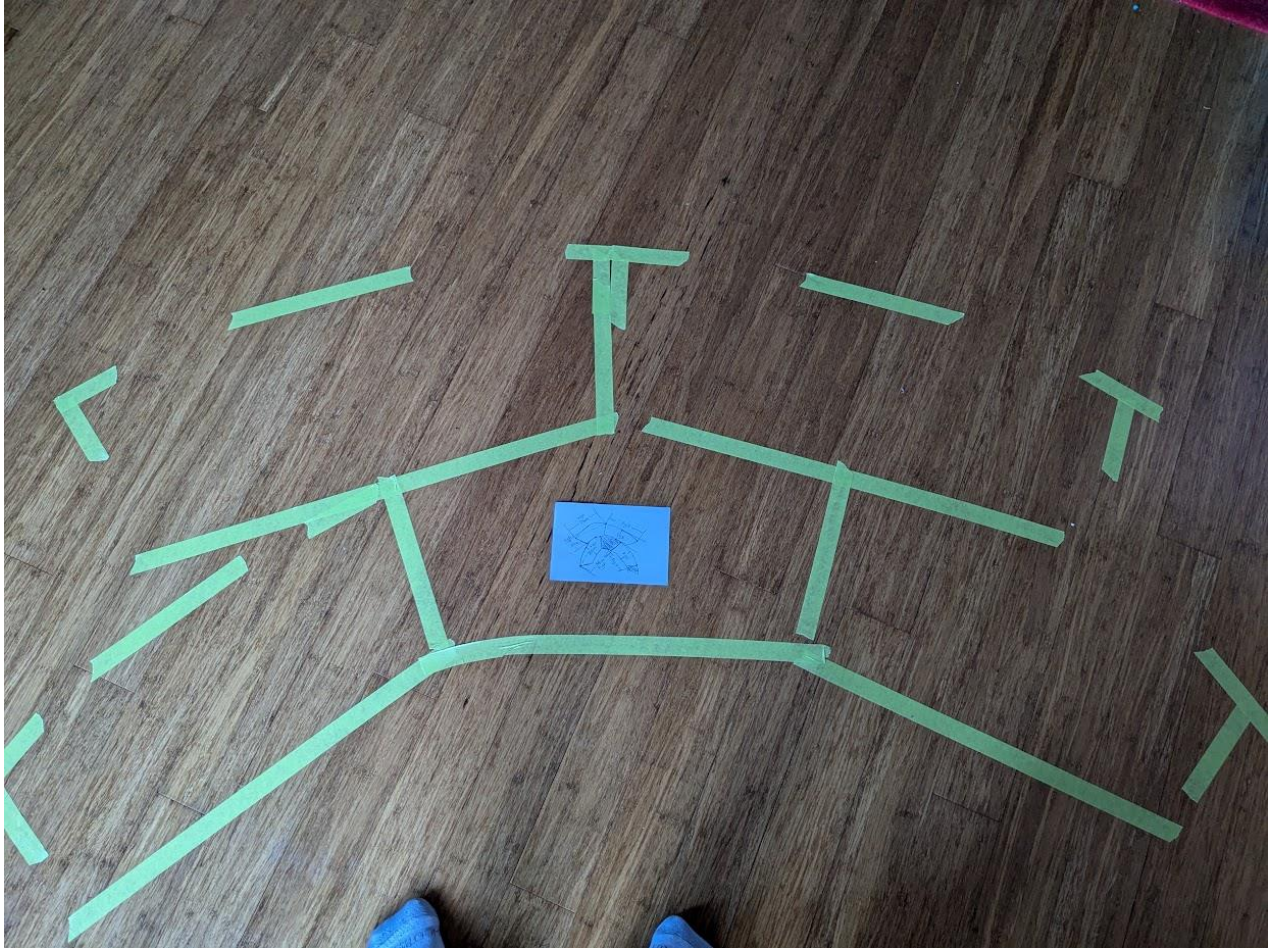


Figure 6-5 Prototyping physical dimensions using masking tape

The final testing step was to trim the borders from the printed scaled slices and then laminate them. The final testing step can be seen below in Figure 6.6. In the end, the game area proved to be a success in terms of fabrication and functionality. However, several issues were identified that should be addressed in the future work of this project. These issues are discussed in section 7.1 of this report.



Figure 6-6 Prototype III testing post trimming and lamination.

6.3 Game Currency Subsystem

The game currency subsystem provides a means for players to take action during the game rounds. It represents money within the game, akin to how the game board provides a space for the players to inhabit during the game. The game master is the principal controller of the currency, although there are other methods to obtain currency. The cards are made of 1/8" MDF material, as can be seen in Figure 6.7, and they have a raster relief cut into them to indicate the color that they match. The relief is painted with acrylic paint to provide visual clarity for the players on which game board area they have matched with.



Figure 6-7 Prototype III Currency

6.3.1 BOM (Bill of Materials)

1. MDF sheets 1/8"
2. Acrylic paint – red/blue/green/yellow/orange/purple

6.3.2 Equipment list

1. Currency Card (20 units)

6.3.3 Instructions

The currency card system interacts with the person selected as the game master. The game master will issue a single currency card at random to each player within the game during each round. The players may occupy a space in accordance with their total collection of currency based on a match color scheme. The currency cards have a secondary objective associated with their function as well. When a player is eliminated from the game, the currency they possess “drops” to the space they occupied and players adjacent to that space may obtain the currency either individually or by even splitting if two players are adjacent.

6.4 Testing & Validation

The design of the cards evolved over the prototyping stages. Initially, they were built from cardboard stock as seen in Figure 6.8 below. This proved to be an inappropriate solution because they lacked durability, aesthetic appeal, and were difficult to hold without dropping or crumpling them. The second prototype moved on to a more durable material, MDF, which was able to withstand the flexing requirements. However, it was still difficult to hold in its circular shape and so prototype III was developed with a rounded rectangular form factor which improved the overall tactile experience.

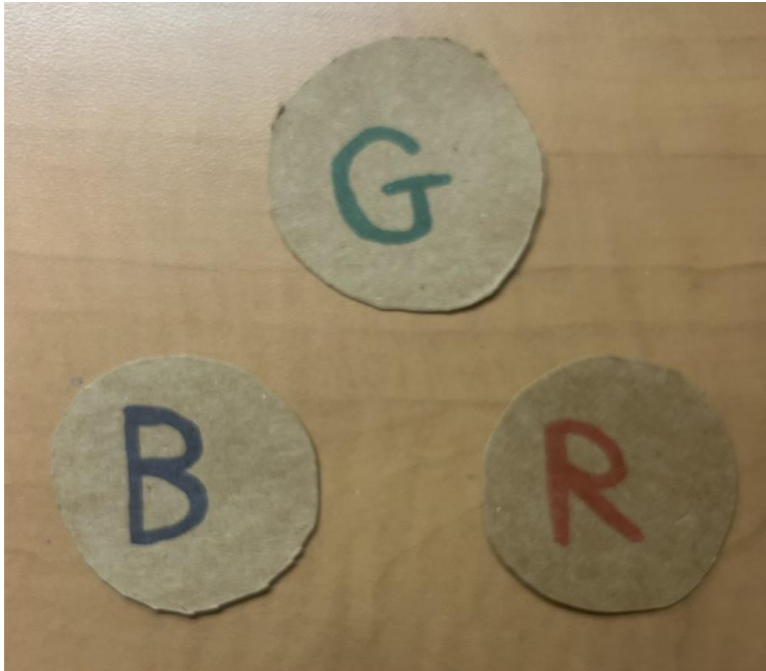


Figure 6-8 Prototype I Game Currency

The key criteria for each stage of testing of the game currency involved the two tests below in Table 6.1. They tested metrics for comfort and durability. The tests results for the prototype I lead directly to the improvements in prototype II and ultimately to the final result in prototype III.

Table 6.1: Key test requirements for the game currency prototyping stages

Test ID	Design Specification	Relation	Value	Units	Verification Method
1	Ability to comfortably hold multiple pieces	=	8 pieces	Pieces	User testing with up to 8 pieces, noting ease of grip
2	Resilience to flexing and repeated handling	>	10 flexes	Flexes	Conduct over 10 flexes to simulate handling effects within a round

6.5 Robotics Subsystem

The robot is the antagonist of the game experience. It is the lethal autonomous weapon system (L.A.W.S) that Mines Action Canada wanted to represent in the message about the dangers of technology and their nine ethical concerns. It is the hunter which systematically eliminates all players from least wealthy to most wealthy and based on their position within the game area. Figure 6.9 shows the Robomaster S1, which is the DJI Robotics technology platform that was used to work on the project.



Figure 6-9 Robomaster S1 Platform Representing a LAWS

At the time of the prototype III stage the robot had three major pieces of functionality, all of which was tested virtually. The first major capability can be seen in Figure 6.10 below where the robot travels in concentric circles around a virtual game space. This angular momentum is part of the robot's pathing behavior which the robot executes each round of the game prior to entering elimination mode. During this mode the robot will move its weapon barrel searching for the person it will eliminate. Once it has located that person's space on the game board it will focus on that player while moving around the game area. Once it has stopped moving, the players will have ceased moving and the robot will enter elimination mode. Since we are unable to actually fire

projectiles, we leverage the LED electronics of the robot to change from green to red to indicate that the player in question has been eliminated.

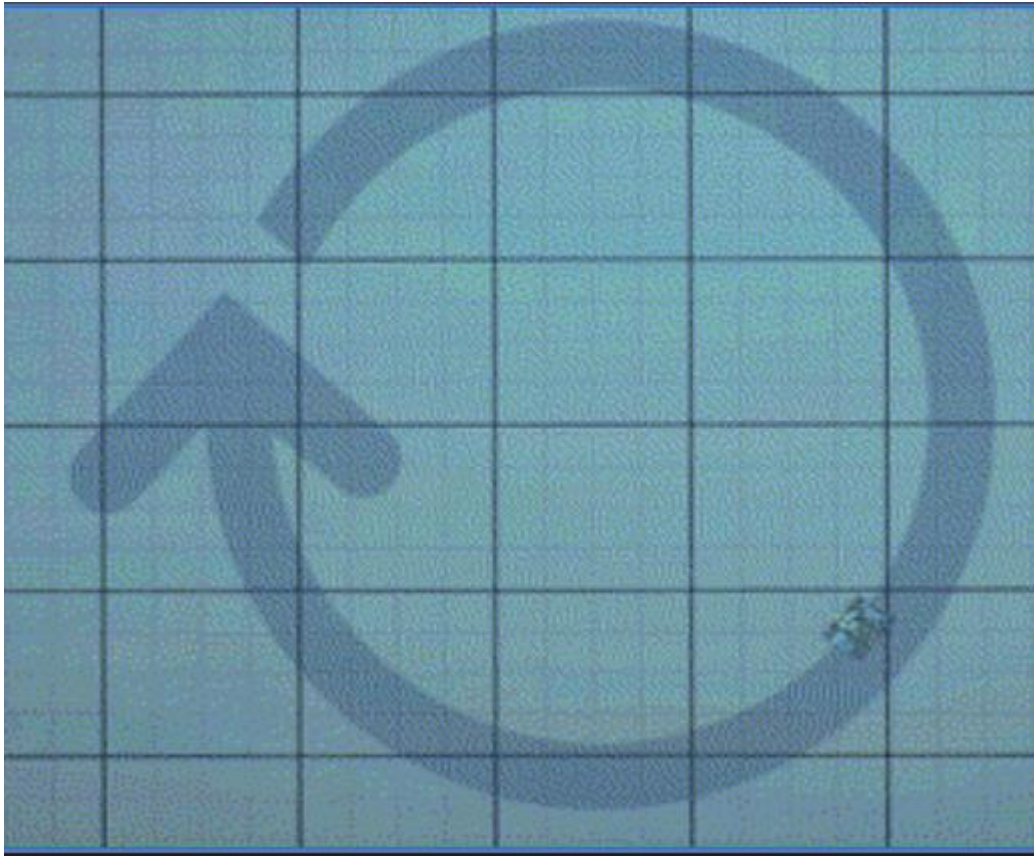


Figure 6-10 Prototype III Fundamental Robotic Motion

The robot will then cease operation for a period of approximately 30 seconds while the game proceeds according to the game rules (see appendix III). Once all players have either been eliminated or migrated from the outer ring of the game area the robot will perform a new navigation procedure by moving one ring into the game area. This maintains a consistent distance between the players and robot and contributes to instilling discomfort in the players. The process of pathing around the circle then continues and alternates with the elimination mode until all players are removed from the game. In Figure 6.11 below the robot functionality is represented with a flowchart.

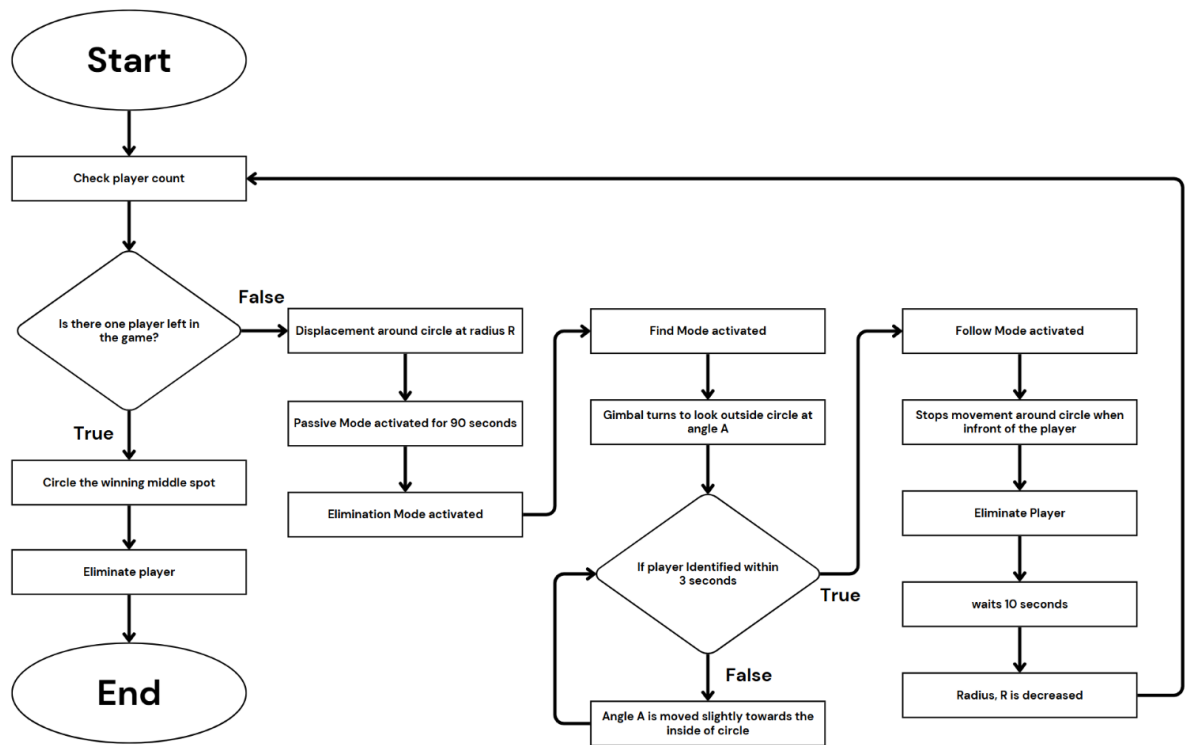


Figure 6-11 Flow chart of the final result of the code

6.5.1 BOM (Bill of Materials)

There is no bill of materials associated with the robot for this project beyond the development of the scratch-based code modules which control the robot. The robot itself was provided by the client.

6.5.2 Equipment list

1. Robomaster S1 robot
2. DJI Education Hub software suite
3. Laptop
4. Code modules for deployment to the robot

6.5.3 Instructions

The code for the robot is deployed wirelessly. The DJI education hub software suite is required to deploy the code. The robot should be placed on the exterior of the game area. Once the modules are installed, the robot will begin its routine. It will continue to operate based on the flowchart above until the final player is eliminated.

7 Conclusions and Recommendations for Future Work

7.1 Conclusion

The development of our game has been quick, forcing us to learn how to mix designing and engineering, all while keeping gameplay mechanics in mind to create an immersive and educational gameplay experience in only 10 weeks. One of our key takeaways was the importance of keeping the user in mind when designing, particularly for accessibility and enjoyment for those with a wide range of needs. Incorporating accessible color schemes and designing for physical mobility constraints showed the significance of inclusivity in gameplay.

If we were given more time, several features would be improved. The gameboard would be redesigned using a single, durable material such as textured PVC to eliminate seams, improving both safety and durability. We would also expand upon the RoboMaster S1's programming with advanced navigation, such as mapping and object detection. Interactive features like audio cues or LEDs on the gameboard could improve the overall immersiveness. Additionally, the currency cards would be remade using more durable materials, such as engraved acrylic, to improve longevity and visual appeal.

Some ideas, such as prolonged testing with larger groups and the development of alternative game modes, were not able to be explored due to time constraints. Future teams could work on

improving upon areas of the project such as implementing more extensive testing or creating a more in-depth experience to both refine the game further and cater to broader audiences.

Furthermore, improving the game's narrative elements or the addition of digital components, such as an app for tracking scores or providing instructions, could also enhance the immersiveness. The biggest takeaway from our project is the importance of time management, when time is limited, it becomes immensely more valuable, so delegating time effectively is the most important aspect of projects such as these and is something future groups should keep in mind.

7.2 Future Work

There are several aspects of the project that require future analysis, design, and fabrication should work be continued on the product. Beginning with the gameboard, there are issues using laminated sheets of paper to construct the gameboard. There is a slip and trip hazard associated with the design because the pieces do not fit seamlessly together. Ideally the board should be constructed from a single piece of PVC material, like the gameboard from the popular game Twister, as this would prevent any tripping hazards from the seams of the gameboard. Based on knowledge from Professor Jim Sykes, Twister also possesses a tactile surface to reduce the chance of slipping when moving along it. This material feature should be included in future construction. Second to the above, the game area should be enlarged to 10'x10' at a minimum to accommodate other players with different physical constraints including overall body shape or the need for wheelchairs or crutches. This would provide a more appropriate space for players from all walks of life.

The game currency is currently constructed of 1/8" MDF. A revision of the game currency should include a material change. The currency was originally conceived as an acrylic piece of art which would represent money in some future setting for the game experience. MDF was chosen for prototype III for economy and durability as compared to a lower cost alternative of cardboard.

Acrylic based game currency would be more durable than MDF, as it would not absorb water, while maintaining a similar weight. The acrylic would be vector cut to a shape roughly the size of a cell phone (6" x 3") and would have a raster relief for the color character (RGB, etc). Similar to the MDF cards from prototype III these acrylic cards would have the color character painted with an acrylic paint.

Finally, regarding work on the robot. Due to limited availability of time and access to the robot much of our work was completed virtually. There is a significant amount of work required to test the robot functionality in the physical environment. The robot's core functions for navigation, detection, and shutdown are all based on non-deterministic data such as angular momentum vs time. This means that the robot's performance would vary based upon the friction and conditions of the surface that it is operating within. Future work should seek to eliminate these uncertainties by developing navigation algorithms that leverage landmarks and mapping of the game area. This would ensure a consistent operation of the navigation systems. The detection systems face similar issues. We were unable to test the detection of colors in our game space and without the ability to identify landmarks the robot might also select a color space without traveling its full rotation (the exterior game circle contains multiples of the same colors).

8 Bibliography

- Mines Action Canada (n.d.), <https://www.minesactioncanada.org/>, accessed on 13 October 2024
- DJI RoboMaster S1 (n.d.), <https://www.dji.com/ca/robomaster-s1>, accessed on 13 October 2024
- WebAIM, “Contrast Checker” (2019),
<https://webaim.org/resources/contrastchecker/>, accessed on 3 November 2024.
- BBC, 'Narrow' South West Trains' seats criticized (2011),
<https://www.bbc.com/news/uk-england-hampshire-12819180>, accessed on 10 November 2024.
- Accessibility Checker “Color Contrast Checker” (2024),
<https://www.accessibilitychecker.org/color-contrast-checker/>, accessed on 10 November 2024.

APPENDICES

9 APPENDIX I: Design Files

Table 1. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Code	MakerRepro https://makerepo.com/eshies/2206.laws-order-	Dec 3 rd 2024
Design_Day_Pamphlets	MakerRepro https://makerepo.com/eshies/2206.laws-order-	Dec 3 rd 2024
Gameboard_Slices	MakerRepro https://makerepo.com/eshies/2206.laws-order-	Dec 3 rd 2024

10 APPENDIX II: Other Appendices

11 Appendix III: Game Rules

The general sequence for play is as follows:

- 1) Game master issues a single currency to each player for that round.
- 2) RoboMaster S1 (bot) initialize period. Players may trade and move. Time: 20 seconds.
- 3) Bot begins patrolling along the outer edge of the circle at fixed velocity. Players may trade and move along the outer circle, or if wealthy enough move deeper within the circle. Time: 1 minute 30 seconds.
- 4) Bot is ready to target a player after completing a circuit. Players will cease moving or trading. Bot targets and eliminates a player. Time: 30 seconds.
- 5) Players nearest the fallen will be allowed to claim dropped resources in a scavenger fashion only within an adjacent position.
- 6) Players will continue to gain resources from the fallen over the game rounds and move deeper into the circle. The robot will eliminate a player each round.
- 7) This process (1-6) repeats until there is only one player left. RoboMaster S1 then eliminates them too and ends the game.

12 Appendix IV: MAC's THEMES

- Digital dehumanization
- Algorithmic biases
- Loss of meaningful human control
- Lack of human judgement and understanding
- Lack of accountability
- Inability to explain what happened or why
- Lowering the threshold to war
- Impact on our relationship to technology
- Destabilizing arms race