Deliverable D - Conceptual Design

2ManyRobots

October 13th, 2024

Abstract

This document will cover current ideas and the state of the project. This will cover the concept generated for the experience, its subsystems, the process in which they were determined, and what the group will ultimately follow through with.

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1 Introduction

The experience involving the robomaster S1 will be in the form of a game, which will be played and experienced by a variety of potential users on design day. The purpose of this document is to catalog the progress of the team and how we designed interchangeable subsystems and parsed them for a final concept with the best combination of qualities.

1.1 Related Work

The Website for the robomaster allowed us to determine technical specifications and features of the robomaster S1. This in turn allowed us to accurately design subsystems specific to the equipment and functionality of the robot.

2 Generating Subsystem concepts

By group discussion, we determined the following subsystems to be relevant divisions of our final solution. Each group member contributed one concept for each subsystem, in order to create diversity of ideas. These suggestions and ideas have been organized below into broad categories in order to display important concepts brought to life by each member of 2ManyRobots.

2.1 User interaction

Ethan
Multiple rounds of varying games displaying different aspects of ethical concerns.
Potential games:

Rounds consist of a player choosing one player to be eliminated by the robot, players also use symbol cards. One player is eliminated by the player selection, and another by symbol card. This displays bias, an inability to explain what happened or why, a lack of accountability, and a lowering of the threshold to war.
The eliminated player will now be on the robot's team (portray it as now that you've been on one side of the robot, you want one on your side now-destabilizing arms race. Displays inability to

explain what happened or why, lack of accountability, impact on our relationship to technology, lack of human judgment. Portrayed as once that the user has been on one side of the robot, they want one on their side, leading to a destabilizing arms race.

Hot potato using robot

- Users stand in a circle while robot patrols.
- Pass around colored symbol cards.
- Robot plays music and stops after a set time.
- Robot scans players to determine elimination based on color held by the player.

Rock paper scissors vs robot

- Selection indicated using speakers for robot, cards for players.

Players attempt to collect objects while avoiding the robot as it patrols. Once all have been collected, the player will be asked to clap twice after which they are eliminated.

Tim

Game rules given by robot to “civilians” (players) as orders. This will lead to the users thinking of the game through a less trivial perspective.

2.2 Robot movement

Charles

The robot has a tracking module or database of its own path, that will then lead the robot according to the presumed path, while adjusting the path according to the environment (avoiding obstacles).

Ethan

Chassis movement to patrol the play area.

Have the turret swivel as if searching. When a player is chosen for elimination, the entire robot will face them and aim laser.

Play area defined in the robot’s programming to prevent it from going out of bounds.

Marked point of origin.

Patrol lines for the robot.

Linh

End-effector or tool component in order to hold, transport, or manipulate objects during gameplay. Allowing physical interaction with the robot, such as object distribution. The robot

could also be in charge of handing items to the users, in a more interactive way for example randomly choosing a user or choosing a user based on a certain article or color of clothing. If this is achieved the users will get to interact with the robot more than if it was just there and not sharing objects.

Tim

Update function and dataset for tracking the position of the robot and relevant game objects. This would include a displacement tracker by recording movements, and parsing of visual objects to their relative position. Smaller functions implemented to simplify geometric calculations such as the new angle to face after displacement. Also allow differentiation of faces by location.

2.3 Robot interaction

Charles

Safety measures applied are able to ensure one cannot come across the robot while in motion.

Ultrasonic or infrared detect sensor array would be used to detect objects or walls around the robot so that the robot can automatically stop or change its direction in case of a collision.

Include the feature of feeling the environment like temperature, humidity or possibly anything else that may interfere with the game.

Temperature sensor that enables it to inform the users or adjust an internal cooling system if external conditions are outside of safe operational limits.

The detection of hand gestures or body movements to support the user to interact with the system.

A robot camera detects basic hand gestures [like waving or pointing] and triggers that robot to perform actions like following a user or stopping movement.

System that enables the robot to change his actions in relation to the user actions or game progression (for example to increase the level of the difficulty).

The challenge for the game gets more aggressive as players do better when the robot's speed and aggression increase dynamically to balance the challenge difficulty.

Integrated emergency switchgear, collision detection and user protection features in order to avoid any accidents during the game.

To protect the robot from a danger like a human or pet getting too close, there's a built-in emergency stop button that can instantly power the robot down.

Ethan

Integrated visual markers with varying symbols and colors. During each round the robot will have code to specify which markers are designated for what position (such as what players to target, can be adjusted manually during gameplay).

Collision avoidance to avoid running into players.

Clapping recognition to detect which player to eliminate.

Motion sensor to detect which player to eliminate.

Sam

Motion detection to notice if a player tries to run away or is attempting to cheat.

Secondary check to see if a player is eliminated alongside symbol recognition.

Lazer should be fired at the abdomen, to avoid lazer being pointed towards eyes, while still allowing its use for indication.

Delay on lazer allowing an attempt to dodge

The robomaster S1 should be able to combine shooting, colors, sound, and maneuverability in order to show the threat that the robot may have

Targets should begin getting closer to the robot as the game progresses in order to elicit discomfort while still provoking a strong interest to play

Symbols used in order to accurately track players and assign data.

Robot scans for symbol then points at the player to be eliminated eyes' by combining the camera with symbol and facial recognition. E.g. If a person wearing a plus is eliminated, the robot records the symbol, points at the player's face, and plays a voice saying something like "Threat wearing plus sign is eliminated, searching for next target".

Linh

System that enables the robot to change its actions in relation to the user actions. This can be used to create a unique game experience for each player and players can have multiple attempts with a new strategy and still have a unique experience.

The detection of hand gestures or body movements to support the user to interact with the system. This can be used when determining the next move of the robot and how it interacts and moves.

Tim

A function that interfaces with the built in AI-modules, querying only relevant things, and returning useful information such as position and human-readable variables. (An issue faced in labs was that symbols simply have numbered IDs).

2.4 Visual & auditory communication

Ethan

-light up and flashes red and plays alarm followed by blaster noise when eliminating target-maybe dun dun duuuuun tones played

-"happy" colours for when the robot is just traversing maybe music or some sort of "happy" sounds -robomaster can

use imported audio or we can program the set notes to play a tune

-audio can be played to represent a given game, somewhat of an interaction between the robot and the players

Sam

The acts of the robot can be expressed using its lights. Red indicates shooting/elimination, Orange indicates a target is found, Blue indicates searching for a target. Green indicates successful elimination, or no current target searching.

Shooting audio should be analogous to real world weapons, such as guns, but not identical as not to provoke discomfort.

A voice that explains the robots actions taken (Possibly robotic, angry, or calm) and reads able out players that were eliminated

Tim

Voice that delivers a quote of "If you or someone you know has been destroyed by an autonomous weapon outside the rules of war, please call XXX-XXX-XXXX. Current wait time: 2750 days". Indicating robotic injustice and delivering emotional impact by connection to frustrating automated service lines.

2.5 Setup

Charles

A rechargeable battery with a power indicator LED (changing color for full, green, medium yellow, and red for low) would allow the robot to charge and indicate battery levels to the driver.

Add-on components such as decorative pieces enable staff to adapt the aesthetic of the robot to different games and/or environments.

Wireless Connectivity, allowing the robot to interact with other devices, such as smartphones and tablets.

By Wi-Fi, the robot can be controlled by a smartphone which makes it convenient for a user to view real time data or to adjust the robot from their smartphone.

Ethan

Users are given an introduction-why-and told game objective.

Swap in battery (multiple batteries needed to prevent down time), run the program, set up player markers (symbols, colors).

Place markers with tape, define gameplay area with tape or rope.

Tim

Brief introduction given by staff (this is a game, do not damage the robot etc.).

Robot orders players (“civilians”) and in the process gives game rules. This should result in more immersion, if the users believe they are following orders rather than playing a game.

Sam

The total weight of the robot should stay the same in order to make sure not to limit mobility.

Slight decorative elements but the weight of the robomaster should remain close to un-modified values.

The robot will do a diagnostic check on design day in the play space, while the story of the game is explained to the players in order to build immersion. Capabilities of the robot are displayed off to the side.

Instructions for the game will be given and symbols will be given to each player to wear or hold.

Staff referee sets up the game and then is “shot” by the robot, indicating the start of the game.

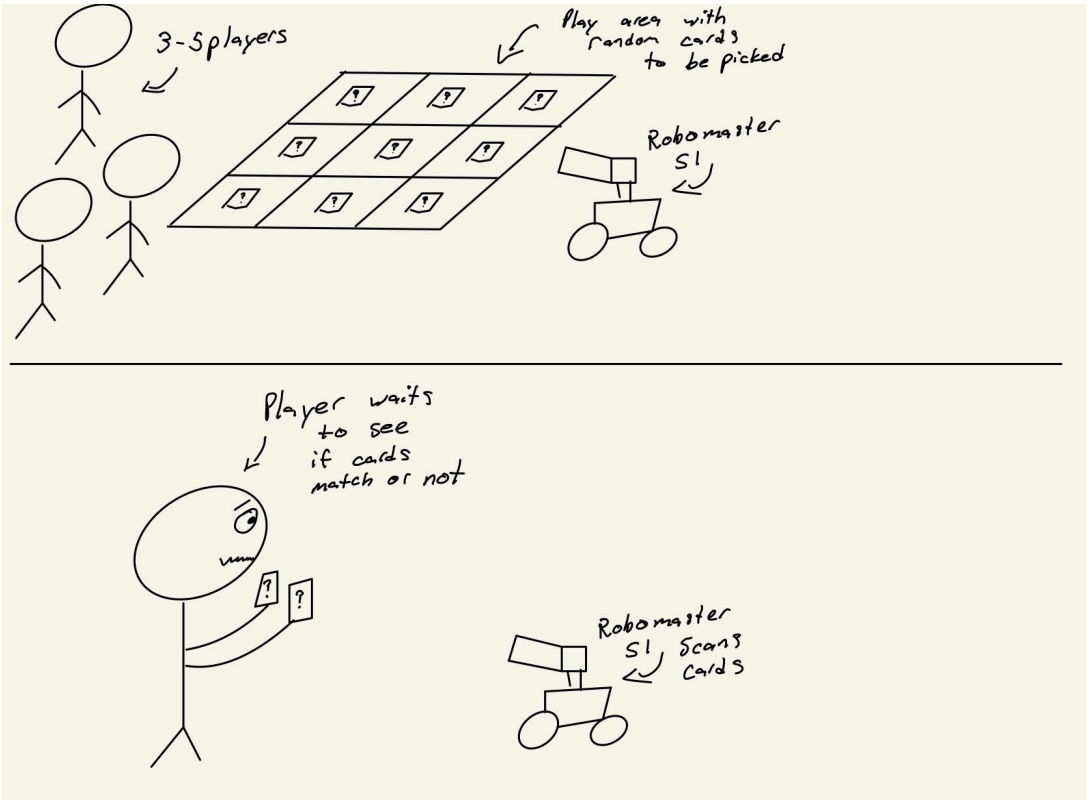
Robot randomly points at a player’s face as the game is explained in order to build fear.

3 Combining the Subsystem concepts

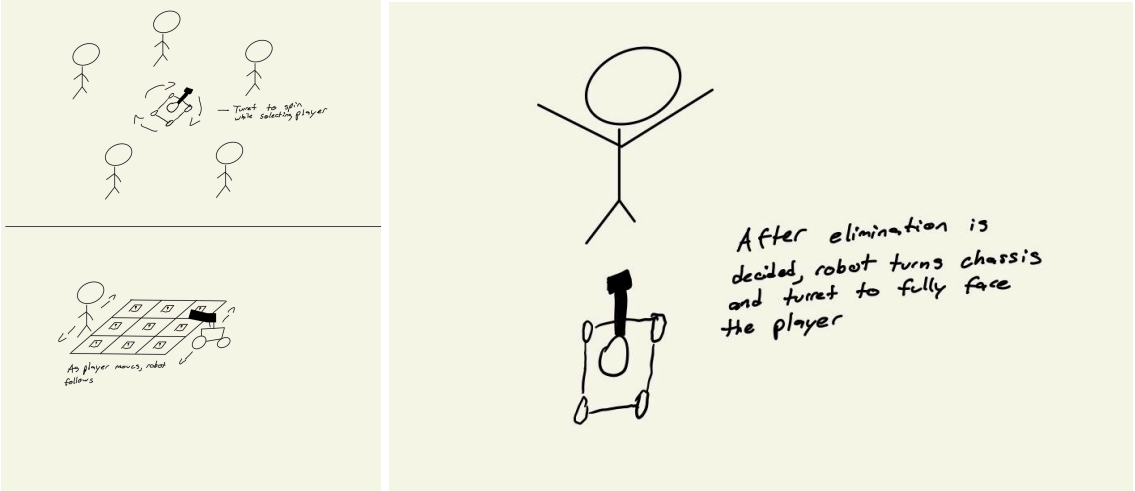
After analyzing, combining, and refining the top individual concepts, we can come up with 3 potential unified solutions. Using the defined subsystems, we interchanged potential concepts to develop our top picks. Everyone’s contributions were carefully analyzed and considered to determine advantages, disadvantages, and feasibility.

3.1 First unified solution

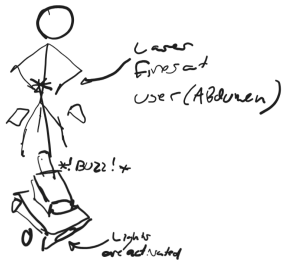
Our first unified solution started from Linh’s idea to have players play a card matching game (user interaction concept). In this concept, players will take turns to traverse the play area and pick two cards of the many placed around the play area. These cards will be marked with varying symbols. The objective of the players is to pick two cards that have matching symbols. The player will then face the robot without looking at the cards to determine if they have been eliminated or not based on if they match or not.



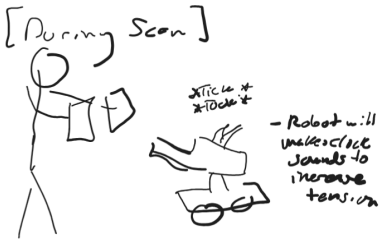
To add an element of suspense, the robot turret will spin in circles before selecting a player's turn (robot movement concept). Once a player is decided to be eliminated or not, the robot will slowly turn to face the player completely (robot interaction concept).



The robot will interact with the users by approaching the player while determining a match or not (robot interaction concept). After scanning the marked cards, the robot will respond with an elimination by shooting the laser and playing a buzzer noise (visual & auditory communication concept).



The robot will use audio to build fear and suspense, such as ticking (visual & auditory communication concept).

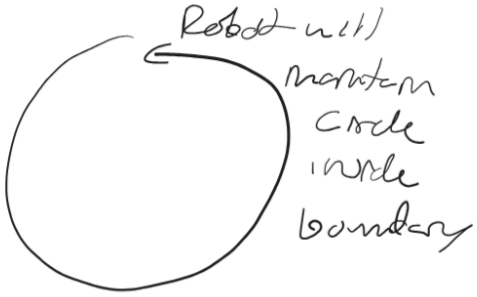


If the robot is not charged enough, there will be extra batteries to swap out (Setup concept). When initializing the game the robot will be placed in the center of the play area, where it has 360 degree vision (setup concept). Players will then be instructed on how the game works and explained the purpose (setup concept).

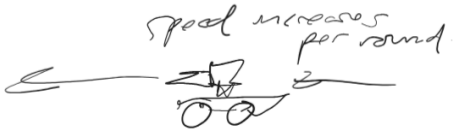
3.2 Second unified solution

Our second unified solution is based on the game “chicken” (user interaction concept). Players are given a symbol, then, players will sit around the robot in a circle, and clap to start & stop robot movement. After some time the robot picks the closest target and eliminates or spares them depending on the symbol assigned. Multiple rounds occur, with the robot eventually eliminating the last player.

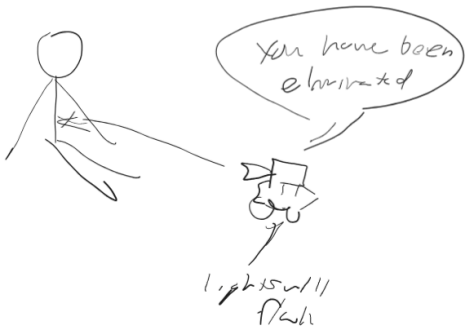
When not controlled by the users, the robot will follow coded movements towards set points (robot mobility concept). A spatial awareness function and dataset will be used to keep track of where the robot is, and prevent it from leaving the play area (Robot mobility concept). Because the robot can move significantly, a collision avoidance system exists to prevent the robot from driving into players (robot mobility concept).



As the game progresses robot movements will speed up, building suspense and fear (robot interaction concept). Face and symbol recognition will be used to determine the closest target and which symbol is theirs (robot interaction concept).



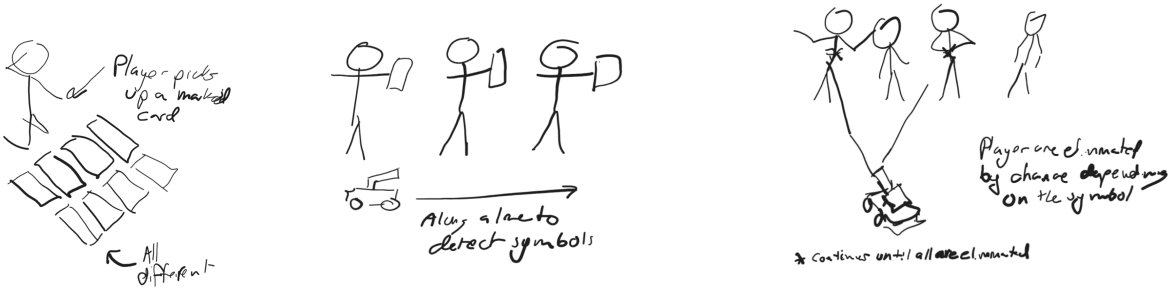
When players are eliminated, the robot plays an announcement indicating this, as well as flashing red lights to indicate elimination (visual and auditory communication concept).



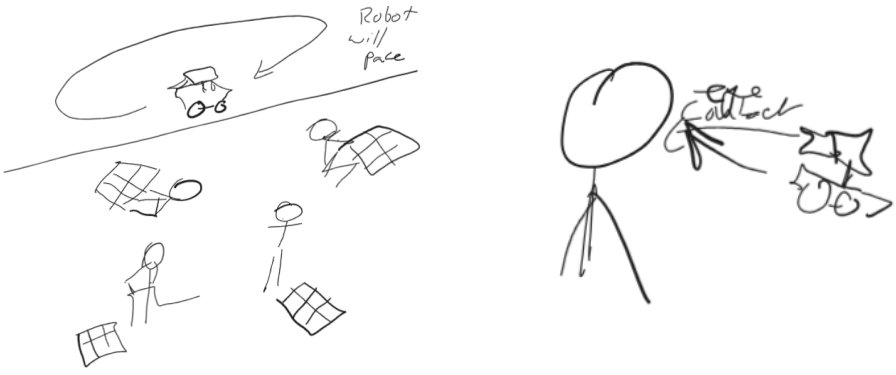
This concept also includes swappable batteries. The robot would be set up in the middle of a ring of players with a diameter of 4 meters (Setup concept).

3.3 Third unified solution

The third unified solution is a hidden game of chance (user interaction concept). The players are given many symbol cards and allowed to pick any of them. The players line up, and the robot eliminates 1-2 players determined by which card they are holding. The criteria for elimination is an arbitrary algorithm that changes between rounds. This repeats until no players remain. The players do not know it is a game of chance, and attempt to determine a pattern to survive.

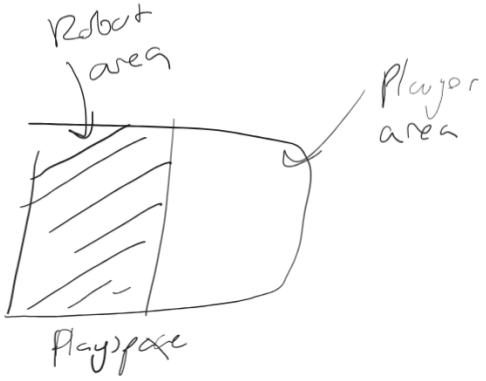


The robot follows a coded path as the users choose cards in separate sections of play area (robot mobility concept). During evaluation/elimination the robot faces the players, and moves along the line (robot mobility concept).The robot avoids collision and quickly reroutes if interfered with by players (robot interaction concept).\



The robot gives the game rules through orders such as “choose the correct symbol to validate your status as a civilian” (visual and auditory communication concept). Lights indicate the robot searching the players, and orange and red lights indicate target acquisition/firing respectively (visual and auditory communication concept).

Tape used to divide the play area into two sections, one for players and the other for the robot (setup concept). Robot is placed on one end of tape to establish origin coordinates (setup concept).



4 Analysis of unified concepts

4.1 Analysis of first solution

Pros:	Cons:
Good suspense as players wait with their selection.	Easy to cheat. (Players may feel they have “beaten” the robot by peaking at cards)
Auditory signaling of elimination is useful	Indeterminate number of rounds.

and engaging.	
Swappable batteries mean good turn-around time.	Elimination rate must be carefully controlled by adjusting which symbol cards are available.
Easy set up	Somewhat difficult to implement.
	May be difficult to hear, no back up to auditory signaling.

Players don’t know what’s going to happen next and it gives suspense. Detection period as sensors are used to read the player cards and decide who gets eliminated gives the experience a feeling of engagement. The robot makes good use of sound to make an impact on players. Setup involves only simple items like cards and area markers, reducing setup time. Implementation requires a very well done positional awareness dataset and calculations, in order to determine which cards are meant to be paired. Another potential drawback is that rounds may or may not eliminate any number of people. All players could be eliminated in the first round, or many rounds may take place before someone is eliminated.

4.2 Analysis of second solution

Pros:	Cons:
Exciting for players.	Very difficult to implement, likely resulting in a high error rate.
Lights are great indicators.	Likely leads to frantic clapping, reducing potential for emotional impact.
Swappable batteries mean good turn-around time.	Clapping is difficult to detect, and is detectable at short range.
Very easy set up	

In the Chicken Game, players have to clap to get the robot to target someone else. This is exciting and very active, and the initial setup is trivial. However upon review

numerous issues come up. Implementation would be very difficult. The range for clap detection is only two meters. Since a combination of audio and vision detection is used, only a limited field of view can be used to scan for claps, as well as this scanning being easily disrupted. The format is also quite silly, and people may clap frantically to avoid the robot, this diminishes the emotional and logical impact.

4.3 Analysis of third solution

Pros:	Cons:
Orders for game rules are immersive.	Random nature could reduce immersion if players realize.
Easy to implement.	Solution does not include a swappable battery.
Easy setup	
Connects well to real-world thinking	

Game rules being given in the format of orders is immersive, and leads to players thinking less trivially. Game is the easiest to implement. Players trying to figure out why the robot eliminates them is engaging and readily leads to real world concerns. Game is likely the easiest to implement. Setup is minimal and can be done quickly. The largest drawback is that if the users realize the game is completely random, they will lose engagement.

4.4 Analysis of concepts as a whole

Criteria	**Concept 1 (Card Collection)**	**Concept 2 (Chicken Game)**	**Concept 3 (Luck Game)**
User Interaction	5	3	5
Robot Mobility	5	3	5
Robot Interaction	4	4	4

Communication	4	3	5
Setup	4	5	4
Ethical Engagement	4	3	5
Challenge and Experience	4	5	3
Safety	5	3	4
Total	35	29	35

We constructed a decision matrix to evaluate the concepts against design criteria. Using themes such as user interaction, robot mobility, robot interaction, communication, setup and experience in general. Scoring in each category will be based on how well the concept fits the respective criteria, on a 1-5 scale. The concept that scored highest will be preferred for further development.

The decision was clearly a race between concepts 1 and 3. After team voting, concept 1 was chosen, with a 4-0-1 vote. This was because it is expected to provide the best experience as a game, while exemplifying moral issues with autonomous weapons well.

5 Selected Final Concept

Solution 1 was chosen as final, although additional concepts from 2 & 3 are added. The flashing red elimination lights are very useful indicators, and will be added from solution 2 to form the final solution. Additionally, the robust dataset and function for spatial tracking will be added from solution 2. Voice commands from the robot from solution 3 will be used to increase immersion.

6 Future Work

The group will continue to research capabilities of the robot and continue to learn programming. As new knowledge is found the concepts may change as newer and better ideas are found and iterated on. By consulting the DJI website we'll be able to better design certain subsystems around the Robomaster S1 and better learn what should change.

During reading week and afterwards the group will reconvene in order to finalize concepts and ideas in person and prepare for the presentation to the client. A series of questions will be formulated for the client meeting on the 22nd, as well as a rough concept for them to criticize and offer suggestions to.

As knowledge of the robot and of coding skills increases, the concept may also be changed as better solutions or solutions deemed too hard may be expunged or changed from the concepts presented above.

7 References

RoboMaster S1 - DJI. DJI Official. https://www.dji.com/ca/robomaster-s1 (Accessed 2024-10-11)