Deliverable D: Conceptual Design

Hassan Rehman

Antonios Sammour

Kailas Ratzel

Aryan Kumar

Kiefer Pomplun

February 9, 2025

Abstract

This report will present the conceptual design development for the use of the Robomaster S1 in a way that addresses three ethical concerns the client has. This document will also use subsystems based off the last deliverable to come up with ideal factors in how the Robomaster S1 will interact and function within its surrounding for its given task.

Table of Contents

1. Introduction

The purpose of this document is to present the conceptual design development for the use of the Robomaster S1 in a way that effectively addresses the three key ethical concerns identified by the client. This conceptual design builds upon the subsystems outlined in the previous deliverable, refining them to optimize how the Robomaster S1 will interact with its environment and perform its designated tasks.

The report details the three core subsystems —Perception and Data Collection, AI Decision-Making, and User Interaction and Communcation. For each of these, multiple concepts were made and evaluated, leading to the development of three system solutions. They were then analyzed using a decision matrix to assess feasibility, ethical implications, and effectiveness.

Following a structured evaluation process, the final concept was selected: a greenhouse plant monitoring system. This design uses the mobility, sensors, and AI processive to assess plant health, detect environmental risks, and assist users in agricultural monitoring while maintaining ethical considerations.

The remainer of the document details the design process, including the subsystems, concept generation, evaluation criteria, and final selection. Additionally, a project plan outlining the next steps for implementation and task assignments is included to ensure efficient execution of the chosen concept.

2. Subsystems for conceptual designs

2.1 Overview of subsystems

The RoboMaster S1 will operate as an AI-driven environmental steward, using its mobility, sensors, and AI processing to analyze plant health, detect environmental hazards, and assist in conservation efforts. The following are the three core subsystems:

1. Perception and Data Collection Subsystem

. Function: Gathers environmental data through sensors and cameras to detect plant health, soil conditions, and environmental hazards like pollution.

. Components:

. Built-in camera (used for detecting plant colour, size, and shape)

. Light sensors to analyze sunlight availability

2. Decision-Making and AI Processing Subsystem

. Function: Uses AI and pre-trained models to process the collected data and determine if a plant is healthy, needs water, or is showing signs of disease.

. Components:

. AI-based image recognition to compare plant conditions against a database of healthy/unhealthy plants

. Human-in-the-loop interventions system – the AI suggests solutions, but the final decision is made by the user

3. User Interaction and Communication Subsystem

. Function: Communicates findings to users through visual, auditory, and digital alerts.

. Components:

. LED lights and sounds to indicate plant status

. Mobile app for notifications

. QR code scanning system to allow users to receive analysis via smartphone

2.2 Concept generation for each subsystem

Perception and Data Collection Subsystem – Concept Variations

Concept Name	Team Member	Description	Pros	Con
Basic Camera Analysis	Hassan	Uses the RoboMaster's built-in camera to identify objects and dangers in the way.	No additional hardware needed, uses existing features.	Limited detection capabilities without additional sensors.
Multispectral Imaging	Antonios	Uses additional sensors to analyze chlorophyll levels and detect plant stress.	More precise plant health detection.	Requires external hardware, increasing cost.
Thermal Detection for Soil Moisture	Kailas	Uses thermal imaging to detect dry soil areas needing water.	Helps determine irrigation needs.	Thermal cameras are expensive and may not be feasible.
Lidar-Based Plant Monitoring	Aryan	Uses Lidar to scan environment to learn its track and surroundings.	Highly accurate measurements, good for long-term tracking.	Lidar is costly and requires additional computing power.

Carbon Dioxide Level Analysis	Kiefer	Uses sensors to detect CO_2 absorption levels in plants, indicating photosynthesis activity.	Provides insight into plant respiration and health.	CO_2 sensors are not commonly integrated into small-scale robotics.

Decision-Making and AI Processing Subsystem – Concept Variations

Concept Name	Team Member	Description	Pros	Cons
Fully Autonomous AI Decision-Making	Hassan	AI detects problems and autonomously applies solutions.	Removes human effort.	Ethical concerns—removes meaningful human control, potential for errors.
Human-in-the-Loop AI Decision-Making	Antonios	AI detects problems and suggests solutions, but the human makes the final call.	Addresses ethical concerns, allows user control.	Requires user intervention.
Pre-Set Plant Health Categories	Kailas	AI classifies plants into basic categories (Healthy, Needs Attention, Critical).	Simple and understandable for users.	Less customization, may not cover all plant conditions.
Crowdsourced AI Improvement	Aryan	AI learns from user feedback over time, refining its recognition system.	Improves accuracy over time, adaptable.	Requires user participation, can be biased.
Predictive Growth Model AI	Kiefer	AI predicts plants health decline before visible symptoms appear.	Proactive plant care, improves long-term health.	Requires extensive plant data for accuracy.

User Interaction and Communication Subsystem – Concept Variations

Concept Name	Team Member	Description	Pros	Cons
LED Light & Sound Alerts	Hassan	Uses RoboMaster's built-in lights and sound cues to communicate and interact with the user.	Simple and effective.	Limited depth of information.
Mobile App Dashboard	Antonios	Displays real-time data and alerts on a mobile app.	Provides detailed insights.	Requires development of a software interface.
QR Code System	Kailas	AI generates QR codes for users to scan and see more specified data in reports.	No need for a dedicated app, easy access to data.	Requires internet access for cloud-based reports.
Augmented Reality Display	Aryan	Users wear AR glasses or use phone cameras to see a plants health overlays.	Immersive experience, visually intuitive.	Requires AR hardware or smartphone access.
Text-to-Speech Alerts	Kiefer	RoboMaster verbally communicates updates.	Accessible for visually impaired users.	Sound alerts may be intrusive in quiet environments.

3. Full system Concept Generation

3.1 Combination of subsystems into potential solutions.

When considering the subsystems form the previous section and combining them, three ideas were created that try to address all three subsystems as well as the ethical concerns presented by the client.

The first concept involves using the Robomaster S1 to aid blind people and deaf people in everyday navigation around the house. For blind people, it would aid via alerting the user of any obstacles in the way. Additionally, the idea of attaching a rope to the robot was considered. To aid deaf people, the robots' lights on the chassis and the gimbal would be used to transmit messages or alerts to the user. This would include alert the user of someone knocking at the door, a potential hazard that can only be heard like an ambulance coming or alerting the user of a danger like a window breaking. This would use the sensors to process any obstacles, the camera for observation of surroundings, use AI to process things as well as the use of the robot's lights and speakers to communicate with the users. This robot would address the ethical concerns for lack of human judgement, by it not

needing to do anything except its job of aiding people. The second ethical concerned addressed is the algorithm bias, which would not be possible for this robot as it would be adapting and forming around the users needs depending on their impairment. Basically, the robot is there to help not to judge. Lastly it addresses the impact on relationship with technology concern, since it would be more of an aid for the user and not a reliance like google or ai is for us. It would simply be a tool at the user's disposal.

The second concept thought of is using the Robomaster S1 as a baby monitor of sorts. This would utilize the robot's decision making on what can harm the baby and would require AI for its recognition of the hazards. It would also utilize the sensors on the Robomaster to avoid obstacles and properly navigate around the house or room. Lastly, the camera would be used to identify objects and determine if it is harmful for the baby. To entertain the baby, it would play music to interact with it, use its lights as visual stimulation and also direct the baby away from hazards by placing itself between the baby and the hazard. However, this concept would only address one ethical concern. The ethical concern is the impact it had on our relationship to technology, by making it a tool to help parents in watching over the baby, while also making the baby have fun and be stimulated it the way it is needed. This idea actually plays into the ethical concerns of the client more than anything due to its digital dehumanization by turning the baby's expressions and actions into data for analysis, lack of human judgement in judging what is safe and unsafe and lack of accountability since any mistakes are just caused by the robot.

The final concept is using the Robomaster S1 in a greenhouse to check and update the user on the status of a plant. It would use its cameras to intake information on the color of the plants leaves, how big a fruit or vegetable is, how dry a soil may be and also scan to see if harvesting is ready or if a plants health is at risk. This would all be processed by an AI with a database contain what the plants should look like, how to tell if a plant is healthy and if a soil needs watering. It would use lights and beeping to alert the user of a problem or if human attention is required. Lastly it would have a set course to analyze all the plants effectively and would use its sensors to avoid any obstacles in the way. This would address three main ethical concerns. The first concern addressed would be algorithmic biases, by highlighting how AI perception can be trained for positive use. The second ethical concern is the loss of meaningful human control which would be addressed by showcasing a human-in-the-loop system for ecological monitoring. The final ethical concern is the impact on our relationship with technology which would be addressed by demonstrating AI as a steward of nature instead of a destructive force, while also being used as a useful tool to help the users.

4. Analysis and Evaluation

4.1 Decision Matrix Evaluation

By creating a list of advantages and disadvantages for each of the three proposed solutions - assistance for visually and hearing-impaired people, working as a baby monitor, and in greenhouse plant monitoring-the best use case selection for the Robomaster S1 can be realized. Each of these solutions will be reviewed in terms of feasibility, ethical consideration, and usefulness.

Solution	Pros	Cons

Aiding Blind and Deaf Individuals	- Very valuable assistance in daily life - Ethically sound, does not rely on human judgment - Adaptable to different impairments	- Requires precise software to reduce false alerts - May need additional hardware for guiding features - Effectiveness reduces during chaos
Baby Monitor	- Uses AI to identify needs of the baby - Entertains the baby with lights and music - Acts as a extra layer of security for parents	- Raises ethical concerns like dehumanization - Could lead to an overreliance on technology from parents - Lack human judgment on dangers - Possible privacy concerns with constant monitoring
Greenhouse Plant Monitoring	- Automates plant health efficiency - Avoids ethical dilemmas as its being used as a tool instead of replacing humans - Uses AI to detect plant health issues	- Requires large data base and lots of training to recognize all plant conditions - Limited to small scale home garden rather than industrial farms

All concepts, according to the pros and cons analysis, have strong and weak aspects. The solution to assist the blind and deaf has great pros in accessibility without losing ethical integrity. The baby monitor concept raises digital dehumanization and privacy questions, making this concept the most ethically controversial. The solution to monitor a greenhouse shows that AI can take a positive stance on environmental sustainability but still needs more improvement in terms of AI accuracy. The best solution is different depending on the core factor that is to be enhanced, such as accessibility, child safety, or agricultural monitoring.

4.2 Selection of final concept

The selected solution to be implemented is the greenhouse monitoring system. This concept effectively leverages the RoboMaster S1 in analyzing plant health, diagnosing possible issues, and sending signals to users when human interference is needed. It covers major subsystems like observation based on cameras, AI-based analysis, and sensor-based navigation to ensure efficiency in plant observations.

The basis of selecting this solution is that it addresses ethical concerns. The Greenhouse Monitor is trying to account for these problems of algorithmic bias by showcasing how AI can be trained in

positive use and not reinforce biases. It is also trying to deal with the problem of a loss of meaningful human control, by using a human-in-the-loop system to make sure the final decision is made by the user. Moreover, this solution has a positive impact on our relationship with technology, placing AI in the role of environmental steward rather than the force for detachment or over-reliance.

Of all the ideas, the greenhouse monitoring system has minimal risks to safety and avoids the issues of digital dehumanization or lack of human judgment. While very commendable applications are helping impaired people and being a baby monitor, they are also more fraught with ethical challenges and require more significant AI calibration in order to be effective. By contrast, the greenhouse monitor is a very practical and ethical use case that increases agricultural efficiency without removing human judgment.

5. Project planning and task assignment

To bring this project to fruition it is imperative that the whole be broken down into manageable chunks and task be split amongst the group. This will be done to ensure that every task is completed smoothly and within a timely manner, while keeping in mind the ethical concerns and usability. Each task will be given a reasonable deadline and have two or more team members assigned to them in order to facilitate teamwork motivation and accountability.

Task	Description	Assigned Team Members	Duration
Research & Ethical Analysis	*Understand AI plant monitoring, ethical concerns.*	Hassan, Antonios	1 week
Sensor & AI Integration	*Implement AI-driven plant health detection.*	Kailas, Aryan	2 weeks
Navigation System	*Ensure smooth movement in greenhouse.*	Kiefer, Antonios	2 weeks
Data Processing & Alerts	*Train AI models, develop alert system.*	Aryan, Kiefer	3 weeks
Prototype Development	*Integrate all subsystems, test functionality.*	Entire Team	3 weeks
Testing & Refinements	*Conduct trials, adjust system performance.*	Kailas, Antonios	2 weeks

Final Evaluation & Report	*Validate results, document findings.*	Entire Team	1 week
Presentation & Demo	*Showcase final design and impact.*	Entire Team	1 week

Using this structured plan, we will ensure the delivery of a thoughtful impactful project that aligns with our objectives and vision while staying practical and realistic.

6. Conclusion (Hassan)

The conceptual design process for the Robomaster S1 has led to our selection of an AI-driven greenhouse plant monitoring system, which balances the technical feasibility, ethical considerations, and practical utility. Through the development of the three subsystems, various concepts were explored and evaluated using a decision matrix.

The final design was chosen based on its ability to address the ethical concerns such as algorithmic bias, meaningful human control, and our relationship with technology. Unlike the other proposed applications, such as aiding visually impaired individuals or working as a baby monitor, the greenhouse monitoring system minimized ethical risks while enhancing agricultural efficiency. This system positions AI as a supportive tool for users rather than a replacement for human judgement, ensuring a balance between automation and human oversight.

In the future, the project will focus on refining the AI model, integrating sensors, optimizing the user interface and developing a testing strategy. The task assignments and project plan outlined in this document guide the next steps for implementation.

Overall, this design highlights how AI and robotics can be used as ethical, efficient, and environmentally conscious solutions to real-world problems. By addressing the key ethical concerns, this project not only advanced the capabilities of the Robomaster S1 but also sets a precedent for responsible AI integration in modern technology.