<u>Grab-n-”Go”ver: RC Car with Robotic Arm</u>

<u>Group 15:</u>

Laila El Banna (*Computer Engineering BSCpE*)

Sanya Wadhwa (*Computer Engineering BSCpE*)

Ryan Kohel (*Electrical Engineering BSEE*)

Michael Patalano (*Electrical Engineering BSEE*)

<u>Reviewers:</u>

Sonali Das

Motivation and Background

The beauty of engineering is how something so small can change the world. A few electrons move in a certain direction, and now you have current flowing through a component. You combine these components together, and you create life-saving technology. We took inspiration from the biomedical field, and started brainstorming all types of ideas for a prosthetic arm. The only problem was the scope of the project. We have four senior engineering students, and we can do better than slapping together some servos and sensors.

We kept thinking about all of the applications for robotic arms and hands, and that led us to a bomb defusal robot. These robots are able to get explosives away from people, and dispose of them in a safe environment. This takes our small idea, and adds way more challenges to it, so we focused on the idea of a remote controlled car that has an arm on top of it, that can grab things and drive around with them.

Through our years of education, we have learned the skills to complete a project such as this. The thing we still need to learn is how to work as a team, all striving towards a common goal. We need to design and create a fully functioning robot that includes dozens of sensors, hundreds of parts, and thousands of lines of code, and we need to do it in a timely and cost effective manner.

Originally, our group was going to create a smart mirror that would display the weather, time, and would have other features such as an alarm clock and being able to play music through Spotify. After careful consideration, our group ultimately decided to create a remote control car with a robotic arm for our project. This idea arose because one of our team members, Michael Patalano, has an interest in robotics. He pitched the idea of creating a prosthetic arm and then we discussed making a robotic arm with a hand and fingers. We decided not to go with the prosthetic arm or the robotic arm idea for the project due to it being too complex because it would require a lot of mechanical parts and the 3-D printing needed for the project would require skills that none of us have. While discussing our project idea, someone had also mentioned a bomb defusal robot so naturally we decided to make a remote control car with a robotic arm for our project. Bomb defusal robots can either defuse the bomb or grab it and move it far away, and ours will be able to grab objects and move them away. This has many more applications, from organizing in factories to building a way stronger robot and moving much heavier objects.

Goals and Objectives

The main goal is to build a remote controlled car, with a robotic arm attached, that can drive around and grab objects. We will also design a companion app. The most important feature is to be able to see what the car sees, by using cameras on the body of the car and displaying it on the app. Some of the other mandatory goals are to control the arm and drive the car simultaneously, place ultrasonic sensors around the car's body to alert the driver of any objects they couldn't see from the front and rear cameras, and include a speaker that can be controlled by the app. The controller moving both parts simultaneously would allow us to move items way faster, which is very important in high pressure situations. The ultrasonic sensors will give the driver feedback about terrain and any incoming objects. The speakers all us to get a message to someone if you are not trying to alert others where the driver is. An underrated goal that we need to reach is the battery life. We want the car to be able to drive for at least an hour, and not only will it be much larger than a normal RC car, but it will have a large arm slapped on top of it. This means more powerful motors, servos, and a larger PCB that can properly disperse the current to all of the components.

Some of the advanced goals we would like to reach include being able to speak directly from the controller to the speaker, headlights with different settings or using a night vision camera, and having the battery life displaced on the app. We are going to use a classic gaming controller that has a place to plug in a headset. The driver could plug in a microphone and speak directly out of the speaker. The realistic goals is hard programming statements into the speaker that will play with a couple of buttons, but this way allows us complete control. We could even put a microphone on the body of the car, and have a conversation with someone standing next to it. The headlights or night vision camera is a very practical addition. It gets dark pretty early in Florida, so having a way to know where you are driving at night is important. We would choose the headlights first, because it is just connecting it to the microcontroller, but the night vision light means programming and additional cost. A regular camera is significantly cheaper than a night vision one. The last feature was about showing the battery life on the app, but it covers all of the features on the car. We only need the app to show the driver where it is going, the rest is extra. Having a screen that controls camera angles, manual subsystem turn offs for battery consumption, controlling the brightness of the headlights, and even a driving setting that retracts the arm for optimal wind resistance in long distance driving is an amazing feature. The less stuff we need to control with the controller the better. This allows the driver for more intuitive driving.

We have a few long term stretch goals, and we will hit some of these, but since we are in the Spring and Summer semesters, it will be much harder to hit all of them. The first one is to use the ultrasonic sensors like a radar detector, and have that be available in the app for the driver. This is most likely not needed, because we will be driving on streets or flat areas, so there wouldn't be terrain to stop the car from driving. Another long term goal is to turn the robot arm from having three degrees of freedom, to four or even five. We are also replicating the hand by using a pincer, but we could make it look like a real hand. This would just be aesthetic, because you could get a much better grip on an item by making the “hand” a pincer. The finger movements would take much more detailed work, and could test our engineering skills.

Features/Functionalities

The Grab-n-”Go”ver is equipped with a range of features to ensure efficient and versatile functionality. An Ultrasonic Sensor facilitates obstacle detection for safe navigation, while a speaker adds an audible element for user interaction and entertainment. Front headlights provide visibility in low-light conditions. The camera offers a visual perspective for enhanced navigation, and Bluetooth connectivity enables seamless communication with external devices. The inclusion of a Controller and App interface ensures user-friendly manual and remote control. DC Motors for the rear wheels and a Steering Servo for the front wheels contribute to precise movement. Notably, a Robotic Arm adds versatility, enabling interaction with objects. Together, these features create a sophisticated yet user-friendly robotic car suitable for diverse applications.

Features	
Ultrasonic Sensor	Controller
Speaker	Mobile Application
Headlights/LED lights	DC Motors For Rear Wheels
Camera	Steering Servo For Front Wheels
Bluetooth	Robotic Arm

The design features of the Grab-n-Go-ver robotic car with a Robotic Arm align with various robotics and IoT projects that integrate sensors, actuators, and multimedia elements for enhanced functionality. Projects such as autonomous robots, robotic arms, and IoT-controlled vehicles often employ ultrasonic sensors, cameras, Bluetooth connectivity, and motor systems for navigation, interaction, and entertainment purposes. Examples of platforms like Arduino or Raspberry Pi-based robotic projects may serve as general references for integrating similar features.

Customer Input and Market Analysis:

The project features have been identified through customer input gathered from surveys, ensuring alignment with user expectations. Additionally, a detailed marketing analysis of comparable products has been conducted to identify successful features and innovative strategies. This input forms the foundation for the following key features:

Advanced Mobility:

Drawing inspiration from various smart robot cars, our robotic machine incorporates high-performance motors, precision control algorithms, and obstacle avoidance sensors. This ensures smooth navigation and collision-free operation, addressing user expectations for a versatile and mobile platform.

Manipulator Arm:

The manipulator arm module focuses on hands-on assembly, flexibility, and educational value. Users can expect a robotic arm that is not only functional but also serves as a learning tool for mechanical principles.

User-Friendly Interface:

Building on the success of user-friendly interfaces seen in existing products, our project integrates intuitive controls for both remote and app-based operation. Customizable settings, inspired by customer preferences, provide an enhanced user experience.In addition, the innovative features of the 360-degree camera, headlights, and music speaker enhance the functionality and user appeal of our robotic machine.

Past Projects

As we begin this project, it is crucial to recognize and utilize insights obtained from existing products, previous projects, and relevant work undertaken in the field of robotics. Two notable references, the Hiwonder Smart Robot Car and the YAZHIYI Robot Arm Building Toy, have been studied in detail to draw inspiration for our project.

Hiwonder Smart Robot Car:

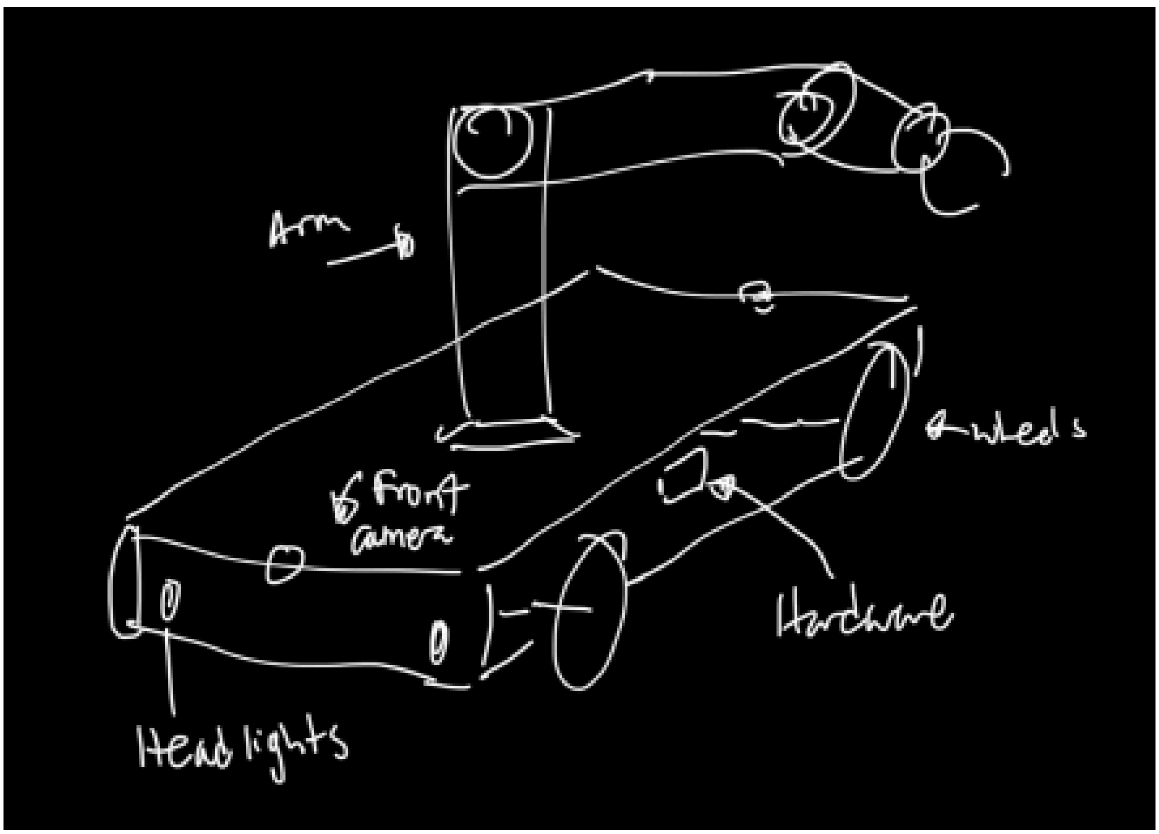
The Hiwonder Smart Robot Car serves as a benchmark in educational robotics, offering a versatile platform for learning electronics and programming. Insights gained from its user-friendly assembly and programmability influence our mobility and control system modules.

YAZHIYI Robot Arm Building Toy:

The YAZHIYI Robot Arm Building Toy provides hands-on experience in mechanical engineering and robotics. Our manipulator arm module draws inspiration from its emphasis on flexibility, adjustability, and educational value, aligning with our goals for a versatile and instructive robotic arm.

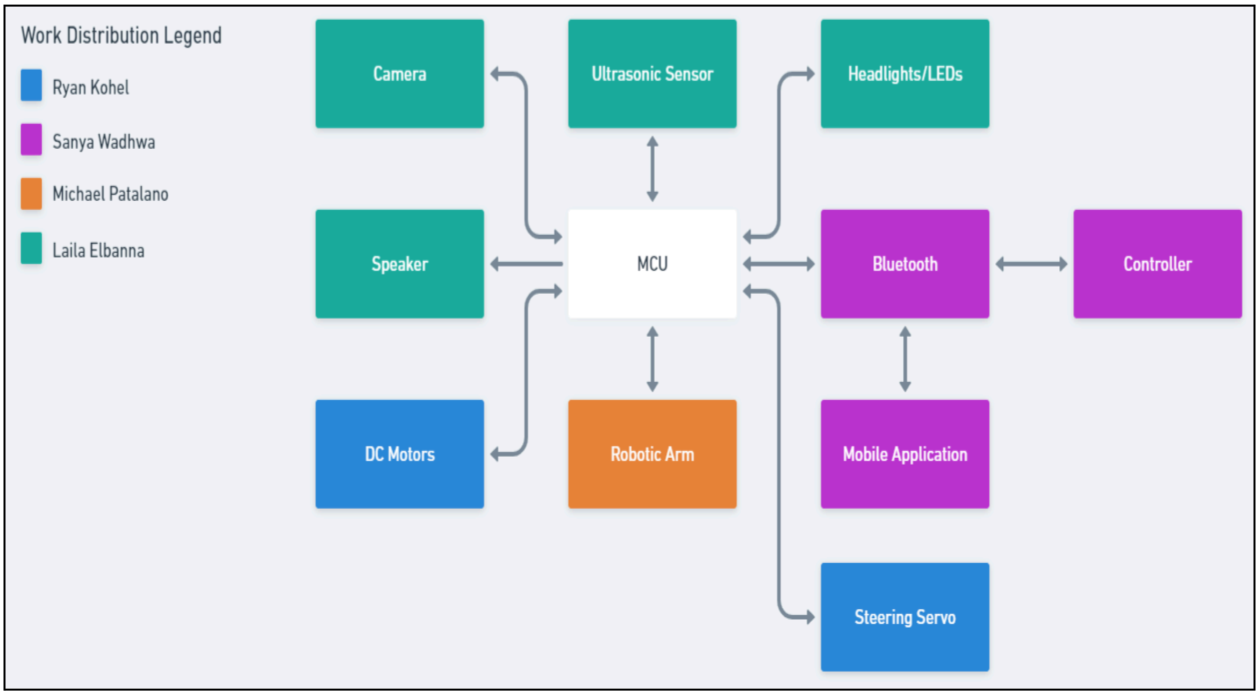
Integration into Our Project:
The features and design principles identified in the Hiwonder Smart Robot Car and the YAZHIYI Robot Arm Building Toy are being integrated into our project modules. This integration aims to capitalize on proven strategies, ensuring that our robotic machine stands out in terms of functionality, user experience, and educational value. By combining customer input, market analysis, and insights from existing products, our project's divide and conquer approach ensures an integrated development process. The features and functionalities identified are not only inspired by successful products but are also tailored to meet the expectations and preferences of our target users.

Prototype Illustration



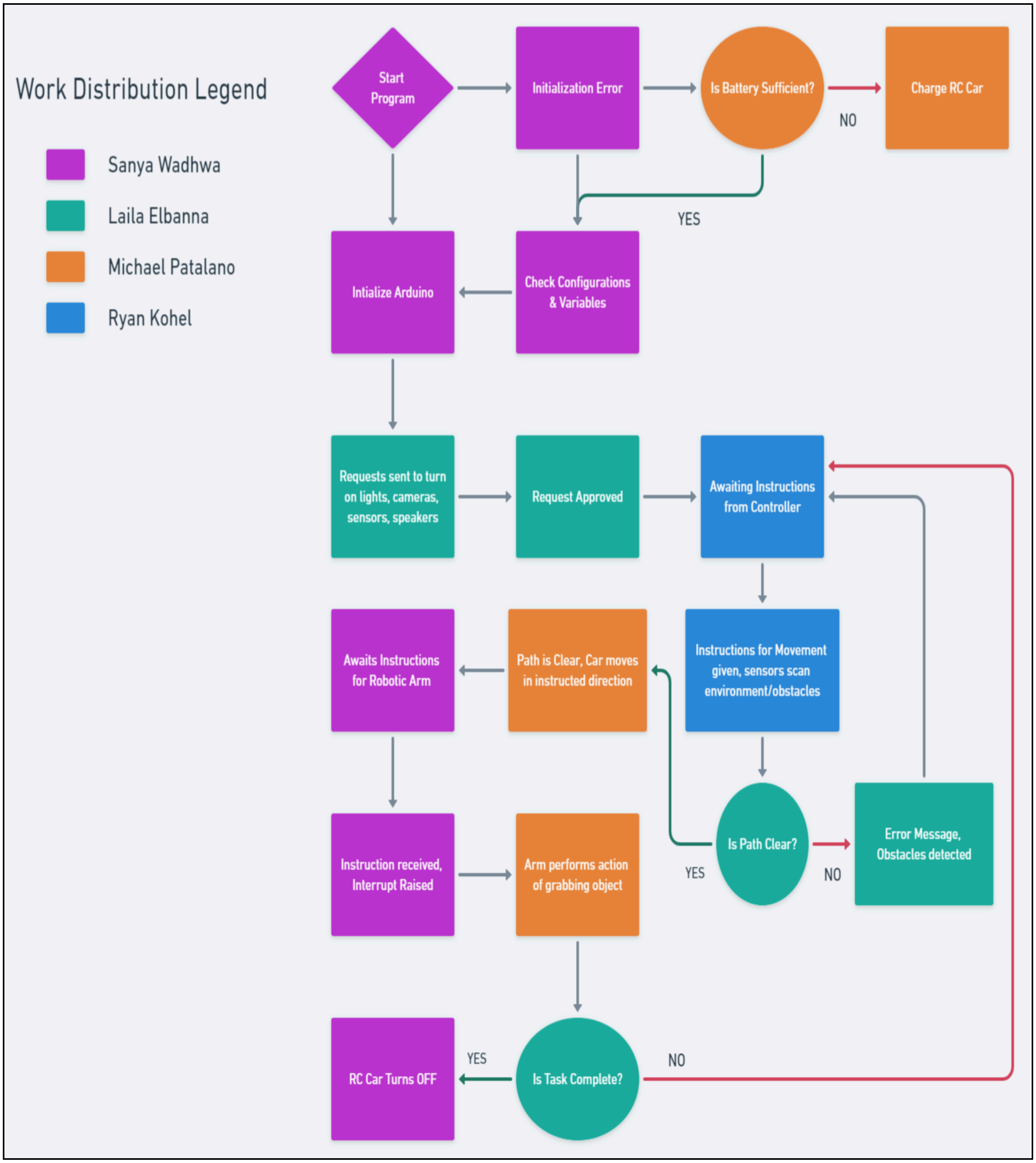
The drawn prototype for the Grab-n-Go-ver serves as a visual representation of the envisioned design. The prototype showcases a well-defined body structure equipped with four wheels to facilitate mobility. Positioned at the front is a robotic arm, providing an extended range of functionalities. The inclusion of headlights enhances visibility in the front, contributing to the overall practicality of the design. Additionally, a camera is strategically incorporated for navigation purposes, allowing users to view the surroundings through a visual feed. The hardware components essential for the car's operation are thoughtfully secured within the central region of the car's body, ensuring a compact and organized layout. This prototype not only captures the physical attributes of the Grab-n-Go-ver but also highlights its potential capabilities, combining both mobility and utility in a single, innovative design.

Hardware Block Diagram

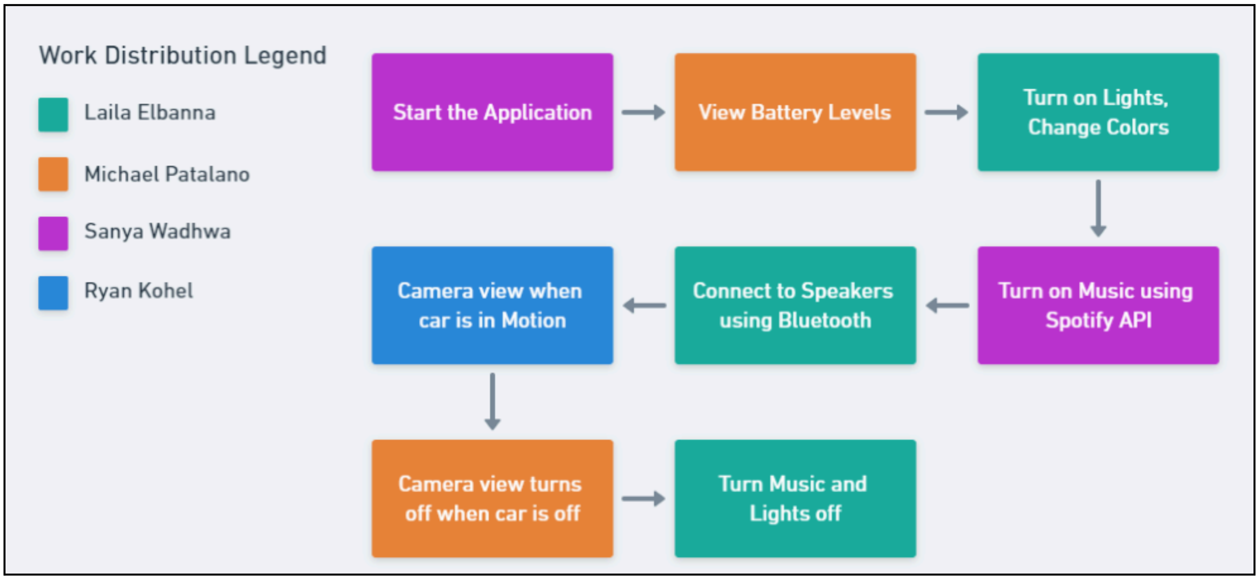


Software Diagrams

The software diagram below illustrates the communication between the Arduino and the controller, detailing the program's execution and functionality. It encompasses the initialization of the Arduino, reading sensor data for environmental awareness, configuring motors and the robotic arm, and receiving user inputs from the controller. The program then assesses sensor data for potential obstacles or targets, determines desired rover movements and robotic arm positions, and executes corresponding commands. Following this, it halts the motors and the arm, culminating in the termination of the program.



The application software diagram below provides a comprehensive overview for various functions of the RC car. It intricately outlines the process of turning lights on and off, allowing for dynamic color changes, and even incorporating music playback through Spotify, enhancing the user experience for entertainment purposes. Additionally, the diagram showcases the functionality of navigation, utilizing the camera view to provide a visual perspective during operation. Beyond that, it introduces a monitoring system for tracking the battery levels of the car, ensuring users are informed about the power status for optimal control and efficient operation of the robotic car. In essence, this application software diagram serves as a visual guide, offering a clear depiction of the diverse and multifunctional capabilities.



Engineering Specifications

Key Specifications
Body of the car must be at least 6 inches in width
Body of the car must be at least 9 inches in length
Battery must be able to power car for at least 1 hour
Robotic arm must be able to maneuver and pick up objects
Car must be able to move forwards and backwards
Car must be able to turn left and right
Cost of the car must be at a maximum of $800 ($200 per team member)
Car must have a turning angle of at least 30 degrees

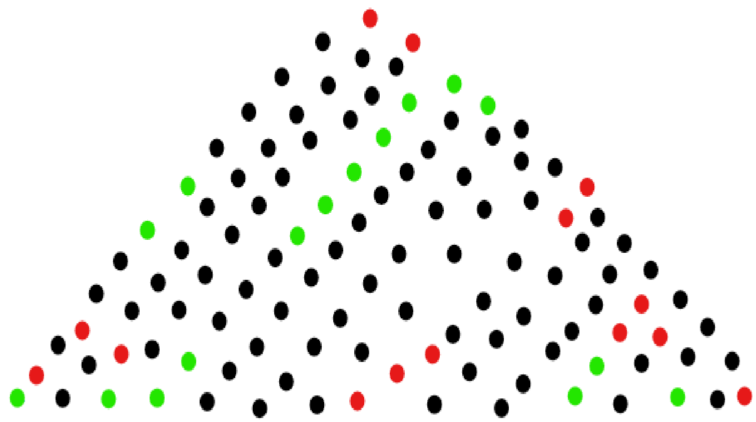
House of Quality

QFD: House of Quality
Project:
Revision:
Date:

Correlations	
Positive	green dot
Negative	red dot
No Correl.	black dot

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼



Column #	1	2	3	4	5	6	7	8	9	10
Direction of Improvement	◇	▼	▲	▲	▲	▲	▲	▲	▲	◇
Customer Requirements (Explicit and Implicit) / Engineering Requirements	Size	Weight	Battery Life	Power Transmission Efficiency	Power Utilization Efficiency	Accuracy	Travel Range Capability	Understandability	Communication Range	Light Range
Power	●	●	●	●	●	○	○	▽	○	▽
Reliabilty	▽	▽	●	○	○	●	○	●	●	▽
Ease of Use	▽	○	○	▽	▽	▽	○	●	●	▽
Compatibility	▽	▽	○	●	●	●	○	●	○	▽
Connectivity	▽	▽	○	●	●	○	○	●	●	▽
Time-Saving	▽	▽	●	●	●	●	●	●	●	▽
Ease of Maintenance	○	○	○	▽	▽	▽	▽	▽	▽	▽
Upgradability	●	●	●	○	○	▽	○	▽	▽	●
Affordability	●	●	●	●	●	○	○	▽	○	●
Portability	●	●	▽	▽	▽	▽	▽	▽	▽	▽
Product Efficiency	○	○	●	●	●	●	●	●	●	○
Target	6" by 9"	Ability to Lift with Ease	Long Battery Life	1-2% Energy Lost during Transmission	Ideal PUE is 1.0	Can grab objects with ease without falling	Travels large distances in a room	Responds to the controller rapidly	Must respond to commands from a different room	A few (3-4) feet of visibility

<u>Budget Breakdown</u>

While we currently lack a designated project sponsor, the funding for this endeavor will be collectively contributed by our group members. We have set a budget ceiling of $800, equating to $200 per person. Although we possess certain testing components such as Arduinos, wires, breadboards, servos, and various sensors, the acquisition of additional project items will necessitate some expenditure.

Component	Cost
Wood (for the car body and arm)	$40
ESP8266 (MCU to control the car)	$15
DC Motors	$20
4 Wheels	$15
Servos (for arm)	$20
Battery	$25
Breadboards, wires, small servos (build a small arm to test code, and then larger one with more powerful servos), ultrasonic sensor, PS4 controller (to drive the car)	Free
Front and rear view cameras (ESP32-CAM Wireless)	$14
PLA filament	$100

Project Milestones / Schedule

	Senior Design 1
Week	**Description and Due Dates**
1-2	Develop a detailed project plan
3-4	Research and Benchmarking
5	Begin the design process for the robotic machine components
6	Create initial prototypes
7-8	Conduct initial tests to validate design concepts
9-10	Present progress to advisors and adjust design plans
11-14	Finalize detailed designs for each module and select specific components, sensors, and materials for construction
15	Assemble a basic prototype to test the integration of key components
16	Perform initial functionality tests

	Senior Design 2
Week	**Description and Due Dates**
1	Address any issues identified
2	Continue refining prototype
3	Begin integrating different modules for comprehensive system test
4-5	User interface and mobile app development
6	Implement customizable settings based on user feedback
7	Conduct extensive system testing to ensure all components work
8-10	Optimize software algorithms for enhanced performance, Final assembly of the robotic machine, Conduct Testing
11-12	Prepare a comprehensive final presentation and documentation & Submit and present the final project documentation

References

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www.ijeter.everscience.org/Manuscripts/Volume-5/Issue-2/Vol-5-issue-2-M-04.pdf

(PDF) Survey of Robotic Arm and Parameters,
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