Gizmo: The Next Frontier in Autonomous Robotics

- Building on Falcon's Legacy

BIA Capstone Project

MGMT – 6134 – 23F

Prepared For:

Professor Mark Bueno

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Prepared By:

PC5I TECHNOLOGIES

TABLE OF CONTENTS

LIST OF TABLES

1. PROJECT CHARTER

1.1. INTRODUCTION

The purpose of this Capstone project is to continue the previous project entitled **"Going into automation: building an Arduino-based intelligent robot to avoid obstacles"** presented by **Team Digi Destined** as part of their requirements for BIA Capstone Project (Summer of 2023) by improving the Robot functionalities, looking for to meet current needs of the society, while we have the opportunity of getting the experience related to robotic, and Fanshawe as institutions keep getting steps into this wide an important field. This enhancement will introduce **Gizmo**. The transition from Falcon to Gizmo symbolizes our commitment to pushing the boundaries of what this intelligent robot can achieve.

Working on this project means opening the door as a team to a new knowledge area that started with a subject like Integrated Systems and Micro Controllers and shows the path to AI, that once is combined with autonomous capabilities offer uncountable opportunities to the society in fields like, health, security, education and so on.

In essence, working on this project is akin to opening a door to a new realm of knowledge and technological possibilities. It signifies our collective effort to not only keep pace with the rapid advancements in the field but also to contribute to the cutting-edge innovations that shape our world. Gizmo, with its newfound capabilities, stands as a testament to our dedication to progress and exploration in the field of robotics.

Together, as a team, we embark on this exciting journey, where Falcon's legacy merges seamlessly with Gizmo's potential, creating a bridge between the past and the future. The path we tread is illuminated by the promise of enhanced autonomy, offering solutions to challenges we may not even fully comprehend yet. Our project represents a significant stride forward, one that Fanshawe as an institution proudly supports as it continues to take bold steps into this wide and important field.

1.2.SCOPE OF WORK

Going further from the previous project there are two main functions that are part of or scope for the current project:

- Obstacle avoidance while driving in route: Adding to the autonomous ability of the robot, we are going to give it the functionality of avoiding obstacles by temporarily going around the obstacle and going back to continue moving through the line route.
- Follow a moving light: The second big improvement of the autonomous robot is including the functionality to detect and follow a moving light, including the capability to move forward, backward, and turn sideways to follow the light target without the need of a tracking line route.

1.3. DELIVERABLES

The Project is also expected to provide the following Deliverables:

1. **Improved Autonomous Functionality**: Enhance the robot's autonomous capabilities to include obstacle avoidance, allowing it to navigate around obstacles and return to the tracking line.
2. **Target Tracing Feature:** Develop a feature that enables the robot to detect and trace light sources, allowing it to identify and follow light patterns while maintaining a defined distance from the source.
3. **User-Friendly Code**: Create clear and well-documented code that is easily understandable by both the project team and potential future project teams.
4. **Live Demonstration**: Conduct a live demonstration of the robot's improved functionalities to showcase its capabilities and functionality to stakeholders.
5. **Documentation**: Provide comprehensive project documentation, including design documents, technical specifications, and user manuals, to facilitate understanding and future maintenance.
6. **Testing and Validation**: Perform rigorous testing and validation of the robot's new features, as well as the existing features, to ensure they work as intended and meet project goals.
7. **Feature Expansion**: As a future deliverable, consider adding more features to the robot, such as additional sensors or functionality, to enhance its versatility and usefulness.
8. **Presentation and Final Report**: Deliver a comprehensive project presentation and a final report summarizing the project's objectives, methodologies, achievements, and future recommendations.
9. **Project Handover**: Prepare the necessary documentation and training materials to hand over the project to a future group, ensuring proper continuity and knowledge transfer.

The project manager, **Wilberto Mejia**, is a key member of the **PC51 Technologies team** and is responsible for managing the development of each project from start to finish. The preparation of comprehensive project plans, attentive oversight of budgets, timetables, and scopes, and ongoing evaluation of project performance are all part of the project manager's duties. By taking a proactive approach, the project manager makes sure that any deviations from the project's course are quickly handled, upholding the highest standards of project excellence. The project manager's steadfast commitment and knowledge make him or her an essential factor in the team's project success.

PC51 Technologies is a team of six teammates.

Core Team Members	
Name	**Student ID / Section**
Wilberto Mejia	1138669 (S32)
Apple Dela Cruz	1080609 (S31)
Jhay-Ar Aguilar	1105965 (S32)
Dean Paul Martin	1091458 (S32)
Anjeline Sayoc	1104192 (S32)
Roben Woo	1080811 (S31)

TABLE 1: TEAM COMPOSITION

Following are the stakeholders involved in this project.

Name	Role
Professor Marc Bueno	Project Mentor
Professor Mona Abou Taka	Project Mentor
Professor Vinicius Rodrigues De Moraes	Project Sponsor

TABLE 2: KEY STAKEHOLDERS

Project Milestone Summary:

High-Level Milestone Timeline				
Milestone	**Description**	**Start Date**	**Status**	**Completion Date**
1	Inception	11 September 2023	Completed	27 September 2023
2	Analysis of Deliverables		On-Going	TBA
3	Design of Deliverables		Not Started	TBA
4	Construction, Results and Discussion of Deliverables		Not Started	TBA
Final Report	Final Report and Evaluations		Not Started	TBA

TABLE 3: PROJECT MILESTONE SUMMARY

SPONSOR ACCEPTANCE

Approved by the Project Sponsor:

_____ Date: _____

2. PROBLEM STATEMENT

Currently, the robot car is lacking two crucial features for autonomous self-driving robots:

1. Avoidance of obstacle while in route

   As of now, the robot car can navigate autonomously through a line track, however, it lacks the capability to detect an obstacle while moving in that route. It cannot autonomously go around obstacles and go back to the route it is taking.

   Without this ability, the robot car is lacking a crucial feature that is important to autonomous self-driving robots. In the real world, we see obstacles like traffic lights, buildings, and any small or big items every day that can hinder its movement.

2. Following a moving target

   As of now, the robot car does not have the capability to follow a target which is in motion, which is also one of the important features a robot car should have in terms of autonomous driving.

In developing this ability, it opens potential opportunities for future growth with regards to autonomously completing tasks. For now, we are developing this via incorporating light tracing functionalities, utilizing the robot car's photoresistors.

3. REQUIREMENTS GATHERING

3.1.1. FUNCTIONAL REQUIREMENTS

Obstacle Detection

- The robot shall employ a ultrasonic ranging module to detect obstacles within a specified range around the car during moving in route.
- The ultrasound system gathers data from multiple directions, evaluates this data independently in each direction, and subsequently manages the car's actions to steer clear of obstacles while moving in route.

Collision Avoidance

- The obstacle avoidance system shall actively control the car's movement to prevent collisions with detected obstacles.
- When an obstacle is detected, the system shall initiate one or more of the following actions to avoid collision:
    - Slow down or stop the car.
    - Steer the car away from the obstacle.

Ultrasonic Wave Emission

- The ultrasonic ranging module shall be equipped to emit ultrasonic waves in a controlled manner.
- The emitted ultrasonic waves shall propagate through the environment and interact with obstacles, causing them to reflect the waves back towards the module.

Time Interval Measurement

- The system shall precisely measure the time interval between the transmission of ultrasonic waves and the reception of their echoes.
- The time difference, measured in microseconds or milliseconds, shall be a reliable indicator of the total travel time of the ultrasonic waves from transmission to reception.

Distance Calculation

- The module shall utilize the measured time interval to calculate the distance to encountered obstacles based on the speed of sound in the environment.
- The distance calculation shall provide accurate and real-time information regarding the proximity of obstacles to the car.

Light Detection

- The car shall be equipped with two photoresistors, strategically placed at the front of the vehicle to detect variations in light intensity.
- The system shall utilize the Analog to Digital Converter (ADC) values obtained from the photoresistors to accurately measure the light intensity.

Light Tracing Behavior

- The car shall be programmed to respond to the detected light source by autonomously steering towards it.
- The degree of steering shall be proportional to the difference in ADC values between the two photoresistors, ensuring precise alignment with the light source.

3.1.2. NON-FUNCTIONAL REQUIREMENTS

Environmental Requirements:

- The robot car shall be designed and calibrated to function effectively on a variety of surfaces, including but not limited to carpets, smooth floors, and rough outdoor terrains.
- The system shall adapt its driving parameters and behavior to ensure stable and reliable performance regardless of the surface type.
- The system shall demonstrate robust performance in varying lighting conditions, including low-light environments and areas with intense light sources.
- The smart car's light tracking behavior shall remain accurate and responsive, adjusting its steering in accordance with changes in light intensity, without significant deviations or errors caused by fluctuations in lighting conditions.

Legal and Licensing Compliance:

- All files, materials, and instructional guides utilized in the development and documentation of this capstone project, including those related to the Freenove 4WD smart car, shall adhere to the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License.
- A copy of this license shall be prominently displayed in the project's documentation and provided with any derivative works.
- The project team shall ensure that any resources, software, or materials utilized are not employed for commercial purposes and are used in strict compliance with the licensing terms and conditions specified.

Performance Efficiency:

- The system shall aim to maximize its operational time on a single battery charge under typical usage conditions.
- The system shall strive to provide responsive obstacle detection and avoidance capabilities to ensure the smart car can efficiently respond in dynamic environments.

Reliability and Availability:

- The smart car shall be designed to operate continuously without any system failures for the duration of its battery capacity, ensuring reliable performance throughout its operational cycle.
- The system shall include built-in fault detection mechanisms to promptly identify and recover from common errors or sensor malfunctions that may occur during the battery's operational capacity.
- In case of a critical system failure within the battery's operational capacity, there should be a straightforward and rapid system restart procedure that allows the smart car to resume normal operation.

Scalability:

- The system architecture shall be designed to allow for easy integration of additional sensors or modules to enhance the smart car's capabilities.
- The software shall be modular and scalable to accommodate future upgrades and improvements without requiring significant code rewrites.

Usability and User Experience:

- The user interface for controlling the smart car shall be intuitive and user-friendly, ensuring that operators with varying levels of technical expertise can easily interact with the system.
- The system shall provide clear and informative feedback to the user, including obstacle detection alerts and status updates, through both visual and auditory cues.
- The smart car shall be designed with a physical emergency stop button that is easily accessible to the operator, allowing for immediate manual intervention in case of unexpected behavior or emergencies.

4. ROLES

ROLES	Description	Resource
Project Manager (Leader)	- Main point of contact between stakeholders, sponsors, and the development team - Lead the team members, define project goals, communicate with stakeholders, and see a project through to its closure - Organizes, plans, and executes the project - Conducts meeting or project checkpoints	Wilberto Mejia
Associate Project Manager	- Assists the project manager in overseeing and managing the project	Anjeline Sayoc
Business / Requirements Analyst	- Understanding and analyzing the business strategies, goals, and requirements - Utilize and compile charts, tables, and other elements of data visualization - Work closely with others throughout the business hierarchy to communicate their findings and help implement changes - Gather, analyze, document, and review system requirements and ensure they are clear, feasible, and complete	Roben Woo Wilberto Mejia
Robot Programmer	- Utilizes and programs using TinkerCAD or Arduino - Codes the robot programs according to requirements - Create unit test cases - Perform unit and system testing according to test cases - Assembles and manages the physical hardware of robot	Anjeline Sayoc Dean Paul Martin Jhay-Ar Aguilar
Quality Assurance Analyst / Tester	- Analyzes and checks the quality of the robot - Creates test cases for unit and system integration testing - Performs the testing of the robot according to the final requirements	Roben Woo Wilberto Mejia Apple Dela Cruz

Documents Specialist	- Consolidate and review document completeness - Proofread documents - Ensure documents quality and availability	Apple Dela Cruz Roben Woo Wilberto Mejia

TABLE 4: TEAM COMPOSITION

5. PLAN WITH EVENT TABLE

The plan for the project is divided into multiple parts over a timeline of 3 months starting from 5th September 2023. The event are as follows:

Summary Project Status	
Project Start Date	September 11, 2023
Estimated Project End Date	December 8, 2023
Impacted Process	
Potential Financial Impact	

TABLE 5: PROJECT STATUS SUMMARY

Milestone Event Table			
Milestone	**Status**	**Due Date**	**Expected Completion Date**
Milestone 1	In Progress	September 27, 2023	September 27, 2023
Milestone 2	To Be Done	October 18, 2023	
Milestone 3	To Be Done	November 8, 2023	
Milestone 4	To Be Done	November 29, 2023	
Final Milestone	To Be Done	December 8, 2023	

TABLE 6: PROJECT MILESTONE SCHEDULE

6. RELEVANCE/SIGNIFICANCE

The Freenove Autonomous Robot Car is a versatile DIY robot kit that can be used in a variety of educational, hobbyist, and practical applications. Here are some of the significance and relevance of autonomous robot cars in the context of robotics and technology.

Education and Learning: Autonomous robot cars, designed for educational purposes, can be highly relevant in teaching students and enthusiasts about robotics, programming, and autonomous systems. They provide hands-on experience and a tangible platform for learning STEM (Science, Technology, Engineering, and Mathematics) concepts.

Skills Development: Assembling, programming, and experimenting with an autonomous robot car can help individuals develop valuable skills in electronics, coding, problem-solving, and project management, which are highly relevant in today's technology-driven world.

Innovation and Creativity: Such robot cars can inspire innovation and creativity among hobbyists and learners. Users can customize and experiment with these platforms to create unique applications, contributing to the evolution of autonomous technology.

Research and Development: Autonomous robot cars serve as platforms for researchers and developers to explore various sensors, algorithms, and technologies related to autonomous navigation, computer vision, machine learning, and artificial intelligence. This is highly relevant for advancements in autonomous systems.

Practical Applications: Depending on its capabilities, an autonomous robot car can have practical applications in fields like agriculture (for crop monitoring), logistics (for automated delivery), or research (for data collection). This practicality makes it relevant to specific industries.

Consumer Products: If the Freenove Autonomous Robot Car is designed for the consumer market, it may provide entertainment or utility features for consumers, such as home automation, surveillance, or interactive experiences.

The relevance and significance of the Freenove Autonomous Robot Car would depend on its specific features, capabilities, target audience, and applications.

7. RESOURCES/GANTT CHART

7.1.1. RESOURCES

The following the needed resources for this project:

Hardware Resources:

- Freenove 4WD Car Kit for ESP32-WROVER (Compatible with Arduino IDE)
- 2 Pack Rechargeable Battery 3.7V 2600mAh Large Capacity Flat Top Li-ion Battery
- Battery Charger
- WIFI
- Laptop
- Mobile Device

Software Resources:

- Integrated Development Environment (IDE) for programming the microcontroller (Arduino IDE)
- Freenove app for Android
- Programming languages (C/C++)
- Simulation and modeling software (if used for testing)
- Documentation and project management tools (e.g., Microsoft Word, project management software)

Human Resources:

- Project Manager
- Associate Project Manager

- Business / Requirements Analyst
- Robot Programmer
- Quality Assurance Analyst / Tester
- Documents Specialist
- Faculty or mentor guidance and support
- Potential collaboration with experts or researchers in the field

Communication and Collaboration:

- Communication tools and platforms for team meetings and discussions
- Access to libraries, research materials, and online resources

Safety Equipment:

- Safety gear, if required for working with certain hardware components

Project Documentation:

- Templates and tools for creating project documentation, reports, and presentations

Presentation and Demonstration Equipment:

- Audiovisual equipment and materials for presenting the project to stakeholders

7.1.2. GANTT CHART

See Appendix 1

8. CLIENT SIGN-OFF

I, **Vinicius Rodrigues**, after a thorough review and comprehensive understanding of the Project Charter for the **" Gizmo: The Next Frontier in Autonomous Robotics - Building on Falcon's Legacy,"** hereby formally signify my endorsement and approval for the project to advance in accordance with the conditions defined in the charter.

I acknowledge the alignment of the objectives, scope, and timeline in the project charter with the capstone project goals and expectations.

By affixing my signature below, I reaffirm my unwavering commitment to actively support the project's success.

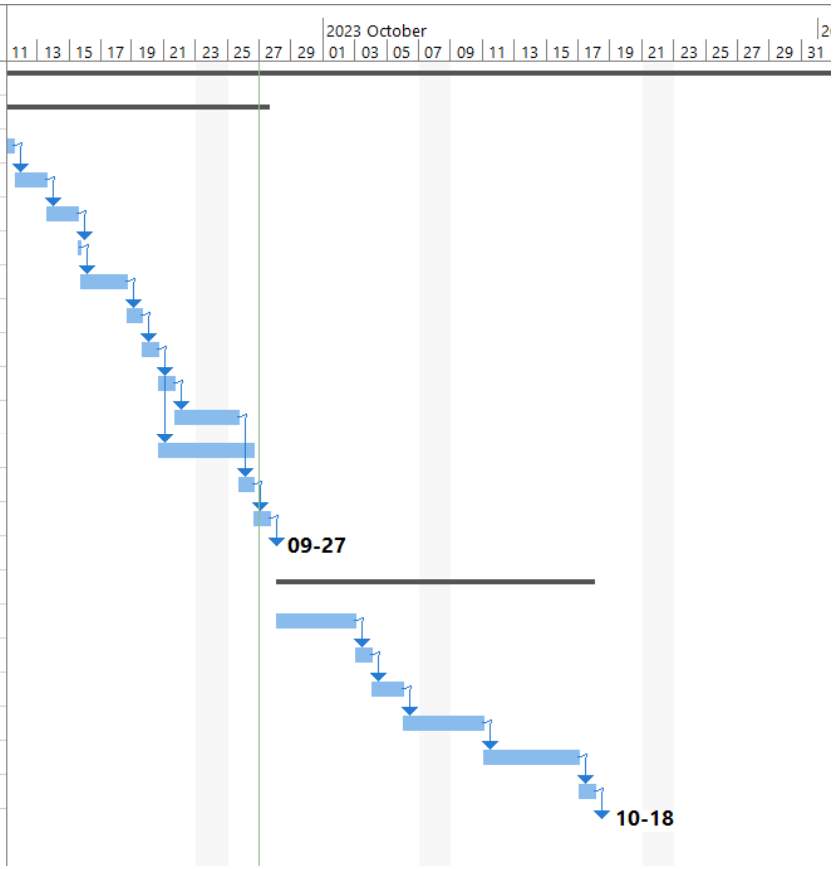
Client Name: Vinicius Rodrigues

Date: 27/09/2023

Signature: _____

APPENDIX 1 – GANTT CHART

ID	Task Mode	Task Name	Duration	Finish	Start	Predecessors
1		**Capstone Project**	**58 days**	**Wed 23-11-29**	**Mon 23-09-11**	
2		**Inception**	**12.75 days**	**Wed 23-09-27**	**Mon 23-09-11**	
3		Team formation	4 hrs	Mon 23-09-11	Mon 23-09-11	
4		Project selection	2 days	Wed 23-09-13	Mon 23-09-11	3
5		Sponsor approval	2 days	Fri 23-09-15	Wed 23-09-13	4
6		Assigment of roles	2 hrs	Fri 23-09-15	Fri 23-09-15	5
7		Logo creation	1 day	Mon 23-09-18	Fri 23-09-15	6
8		Project charter	1 day	Tue 23-09-19	Mon 23-09-18	7
9		Project scope	1 day	Wed 23-09-20	Tue 23-09-19	8
10		Gantt chart	1 day	Thu 23-09-21	Wed 23-09-20	9
11		Requirement gathering	2 days	Mon 23-09-25	Thu 23-09-21	10
12		Hardware analysis	4 days	Tue 23-09-26	Wed 23-09-20	9
13		Relevance	1 day	Tue 23-09-26	Mon 23-09-25	11
14		Sponsor Sign-Off	1 day	Wed 23-09-27	Tue 23-09-26	13
15		Milestone 1: Inception	0 days	Wed 23-09-27	Wed 23-09-27	14
16		**Analysis**	**14 days**	**Wed 23-10-18**	**Thu 23-09-28**	
17		Web Search	3 days	Mon 23-10-02	Thu 23-09-28	
18		Use case Diagrams	1 day	Tue 23-10-03	Tue 23-10-03	17
19		Class Diagrams	2 days	Thu 23-10-05	Wed 23-10-04	18
20		Prototype - Draft	3 days	Tue 23-10-10	Fri 23-10-06	19
21		System Architecture - Draft	4 days	Mon 23-10-16	Wed 23-10-11	20
22		Data Dictionary - Draft	1 day	Tue 23-10-17	Tue 23-10-17	21
23		Milestone 2: Analysis of Deliverables	0 days	Wed 23-10-18	Wed 23-10-18	22



ID	Task Mode	Task Name	Duration	Finish	Start	Predecessors
24		**Design**	**14 days**	**Wed 23-11-08**	**Thu 23-10-19**	
25		System Architecture	2 days	Fri 23-10-20	Thu 23-10-19	
26		ER Diagram	2 days	Tue 23-10-24	Mon 23-10-23	25
27		Data Dictionary	2 days	Thu 23-10-26	Wed 23-10-25	26
28		Updated Prototype	5 days	Thu 23-11-02	Fri 23-10-27	27
29		Test Cases - Draft	3 days	Tue 23-11-07	Fri 23-11-03	28
30		Milestone 3: Design	0 days	Wed 23-11-08	Wed 23-11-08	
31		**Construction**	**15 days**	**Wed 23-11-29**	**Thu 23-11-09**	
32		Development	6 days	Thu 23-11-16	Thu 23-11-09	
33		Testing	2 days	Mon 23-11-20	Fri 23-11-17	32
34		Bug debugging	3 days	Thu 23-11-23	Tue 23-11-21	33
35		Initial Demo for the Advisor	1 day	Fri 23-11-24	Fri 23-11-24	34
36		Recommendations	1 day	Mon 23-11-27	Mon 23-11-27	35
37		Summary	1 day	Tue 23-11-28	Tue 23-11-28	36
38		References	1 day	Wed 23-11-29	Wed 23-11-29	37
39		Milestone 4: Construction	0 days	Wed 23-11-29	Wed 23-11-29	38