DESIGN AND DEVELOPMENT OF A TRACKLESS AUTONOMOUS VEHICLE USING LINEAR MOTOR STEERING CONTROL

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2024

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A report submitted
in partial fulfillment of the requirements for the degree of
Electrical Engineering with Honours

Faculty of Electrical Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

DECLARATION

I declare that this thesis entitled "DESIGN AND DEVELOPMENT OF A TRACKLESS AUTONOMOUS VEHICLE USING LINEAR MOTOR STEERING CONTROL is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this report entitled " Design and Development of A Trackless Autonomous Vehicle Using Linear Motor Steering Control ", and in my opinion, this thesis fulfills the partial requirement to be awarded the degree of Bachelor of Electrical Engineering with Honours

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DEDICATIONS

I express my gratitude to Allah, the Almighty, for granting me the knowledge, commitment, and strength to accomplish this report. Dear, my beloved parents, grandmother, and little sister.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation and gratitude to those who have contributed to the completion of this essay titled " Design and Development of A Trackless Autonomous Vehicle Using Linear Motor Steering Control."

First and foremost, I extend my deepest thanks to Prof.Madya.Ir. Ts. Dr. Abdul Rahim Bin Abdullah, for their insightful guidance and constructive feedback throughout the entire writing process. His expertise and dedication to fostering academic growth have been instrumental in shaping the content and structure of this essay.

I would also like to acknowledge the support and encouragement of my classmates and peers who engaged in meaningful discussions, provided valuable perspectives, and offered constructive criticism. Your collaborative spirit has greatly enriched the depth and breadth of the ideas presented in this essay.

To my family and friends, thank you for your unwavering support and understanding during the countless hours spent researching and writing. Your encouragement has been a driving force behind my commitment to producing quality work.

I express my gratitude to the Universiti Teknikal Malaysia Melaka (UteM) for providing a conducive learning environment and access to resources that facilitated the research and development of this essay.

Last but not least, I acknowledge the importance of self-reflection and personal growth in the writing process. The challenges faced and lessons learned have been invaluable in the development of my writing skills. This essay stands as a collective effort, and I am sincerely thankful to each individual and resource that has played a role in its completion.

ABSTRACT

The transportation industry faces significant challenges with conventional vehicles, which struggle to adapt to diverse environments and ensure precise navigation. These limitations underscore the growing demand for advanced autonomous vehicle technology capable of safe and efficient operation across varied terrains. Addressing this need, the project "Design and Development of a Trackless Autonomous Vehicle Using Linear Motor Steering Control" proposes an innovative solution by integrating a linear motor steering system with an Arduino-based platform. The main objective of this project is to improve the self-sufficiency, precision, and adaptability of self-driving vehicles, hence eliminating the requirement for conventional rails. The main objective of this project is to design a specialized vehicle construction that is specifically optimized for autonomous operations. The implementation of a highly responsive linear motor steering system is essential to the performance of the device. This method allows for precise control without the limitations of traditional steering mechanisms. The project intends to utilize the benefits of linear motor steering in autonomous vehicle design, while also tackling the issues that come with it, through thorough investigation and analysis of current literature and technology. The integration phase focuses on combining sensors, actuators, and the linear motor steering system using Arduino software, laying the groundwork for prototype development..The main focus of this project is to create substantial advancements in autonomous vehicle technology, providing a sustainable and efficient solution for various transportation requirements. It aims to set new standards in the deployment of autonomous vehicles, especially in urban and rural areas, by improving navigation flexibility, precision, and safety. The project's innovative methodology ensures that self-driving vehicles can function independently and efficiently, hence enhancing the progress of transport networks towards more flexible and effective solutions.

ABSTRAK

Industri pengangkutan menghadapi cabaran signifikan dengan kenderaan konvensional, yang mengalami kesukaran untuk menyesuaikan diri dengan pelbagai persekitaran dan memastikan navigasi yang tepat. Kelemahan ini menekankan permintaan yang semakin meningkat untuk teknologi kenderaan autonomi yang canggih yang mampu beroperasi dengan selamat dan efisien di pelbagai medan. Menangani keperluan ini, projek "Reka Bentuk dan Pembangunan Kenderaan Autonomi Tanpa Trek Menggunakan Sistem Pemacu Motor Linear" mencadangkan penyelesaian inovatif dengan mengintegrasikan sistem pemacu motor linear dengan platform berdasarkan Arduino.Objektif utama projek ini adalah untuk meningkatkan kebolehan sendiri, ketepatan, dan adaptabiliti kenderaan pemanduan automatik, dengan menghapuskan keperluan untuk landasan konvensional. Fokus utama adalah untuk mereka bentuk struktur kenderaan yang khusus dioptimumkan untuk operasi autonomi. Pelaksanaan sistem pemacu motor linear yang sangat responsif adalah penting untuk prestasi peranti ini, membolehkan kawalan yang tepat tanpa batasan mekanisme kawalan tradisional.Projek bertujuan untuk mengambil manfaat dari penggunaan pemacu motor linear dalam reka bentuk kenderaan autonomi, sambil menangani isu-isu yang berkaitan melalui penyelidikan dan analisis mendalam terhadap literatur dan teknologi semasa. Fasa integrasi menumpukan kepada gabungan sensor, aktuator, dan sistem pemacu motor linear menggunakan perisian Arduino, membuka jalan untuk pembangunan prototaip.Fokus utama projek ini adalah untuk membuat kemajuan yang ketara dalam teknologi kenderaan autonomi, menyediakan penyelesaian yang lestari dan efisien untuk pelbagai keperluan pengangkutan. Ia bertujuan untuk menetapkan standard baru dalam penempatan kenderaan autonomi, terutamanya di kawasan bandar dan luar bandar, dengan meningkatkan fleksibiliti navigasi, ketepatan, dan keselamatan. Metodologi inovatif projek ini memastikan bahawa kenderaan pemanduan automatik dapat berfungsi secara bebas dan efisien, menyumbang kepada kemajuan rangkaian pengangkutan ke arah penyelesaian yang lebih fleksibel dan efektif.

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LIST OF SYMBOLS AND ABBREVIATIONS

BLDC	-	Brushless DC Motor
CWA	-	Cycling Without Age
D,d	-	Diameter
GPS	-	Global Positioning Sensor
h	-	Hour
Km/h	-	Kilometer per hour
GPS	-	Global Positioing Sensor
IOT	-	Internet of Things
UTeM	-	Universiti Teknikal Malaysia Melaka

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Vehicles that drive themselves are becoming more and more integrated into the lives of humans, which opens up new commercial prospects for many businesses and research opportunities for educational institutions throughout the world. The aforementioned categories are all examples of fields in which academics design research initiatives to address societal concerns and satisfy society's demands. The availability of funding, in addition to the capabilities, experiences, and competence of the researchers, are also taken into consideration while deciding on research projects. Because there have been a significant number of inventions and breakthroughs in robotics and automation, governments are required to train individuals to not only behave as followers (to handle innovation), but also to behave as leaders about some elements of innovation. This is because such innovations and breakthroughs have occurred. The technology behind autonomous vehicles has an effect on human existence in a way that lowers the expenses of transportation, the number of deaths that occur as a result of car accidents, and the number of deaths overall, while also minimizing the risk of financial loss.[1]

1.2 Introduction

An autonomous bicycle is a high-efficiency vehicle robot that needs optimal management. Autonomous vehicles are becoming increasingly involved in humans' daily lives and create business opportunities for industries and research opportunities for universities. The modeling and control of autonomous vehicles have become long-standing goals in applied mathematics, computer sciences, and engineering. In each of the above-cited fields, researchers design research projects to address societal challenges and meet societal demands. There have been a considerable number of innovations and breakthroughs in robotics and automation, requiring governments to train people to not only behave as followers (in order to handle innovation) but also to behave as leaders regarding some aspects of innovation.

Autonomous vehicle technology impacts human life in a way that reduces transport costs, the number of car accidents and the number of deaths, as well as minimizing financial risk. Reports made by the transport departments of certain countries have shown that autonomous vehicles can minimize the number of deaths caused by car crashes , thus contributing to optimal fuel management and storage, contributing to the minimization of transport costs and saving approximately hundreds of billions of dollars for society as a whole.

Despite the fact that robotics significantly and considerably impact human activities, human assistance during robot motion still remains relevant because of certain technical issues, which may suddenly arise during vehicle motion and are beyond the provided and embedded software and hardware. Study aimed at examining the impact of the reaction wheels on the stability of an autonomous bicycle.

1.3 Problem Statements

Traditional vehicles equipped with conventional steering mechanisms such as wheels, face limitations in terms of terrain adaptability and precise navigation. These vehicles are often constrained by the need for well-maintained roads or surfaces, making them less versatile for certain applications. Human operators play a crucial role in the design and development of trackless autonomous vehicles that utilize linear motor steering control. It play a role in conceptualizing, planning, and designing systems, as well as managing real-time monitoring and emergency action. As the vehicle progresses, the proportion of human intervention lowers, to achieve higher autonomy and obedience to regulations. With the progression of technology, the need for human operators reduces.

Reduced steering system operational capability can be caused by various factors, including linear motor malfunctions, control system issues, power supply irregularities, environmental factors, system integration issues, maintenance practices, external interferences, and safety protocols. A comprehensive testing, simulation, and validation approach is crucial for handling emergencies and ensuring vehicle autonomy. Continuous monitoring, diagnostics, and a robust maintenance plan are essential for maintaining the linear motor steering control system's reliability and safety.

This limitation reduces linear motor steering system precision and resolution, which may influence vehicle navigation. Precision can be compromised by many reasons, including sensor accuracy and calibration for vehicle location, orientation, and surrounding. The linear motor's resolution and accuracy are important. Control algorithm complexity, external interference, system integration issues, and component wear and tear lead to inaccurate steering. During development, rigorous testing, simulation, and validation are used to improve control algorithms, calibration methods, and system component compatibility. The autonomous vehicle's dependable and precise steering performance depends on regular maintenance and calibration of the linear motor steering control system to reduce wear and maintain accuracy.

To assure safety, the development of a trackless autonomous vehicle requires a comprehensive and diversified strategy. This encompasses resilient collision avoidance technologies, fail-safe mechanisms, , efficient communication, adherence to safety standards, adaptation to various situations, thorough testing, and education on the vehicle's capabilities. Furthermore, it is important to take into account ethical factors, such as developing programming that prioritises ethically upright decision-making. The vehicle's safety is maintained at a high level throughout its operating lifespan by regular upgrades, strict adherence to increasing safety regulations, and continual performance monitoring.

In summary, this project proposed Autonomous Trackless Vehicle that will pave the way for a more efficient, cost effective and worker-free solution in the real of trishaw transportation. The focus on versatility and precision in navigation makes this technology promising for a range of applications that require autonomous vehicles to operate in varied and unpredictable environments.

1.4 Objectives

The objective of this research as follows:

i. To design a trackless autonomous vehicles platform based on Arduino-based control system.

ii. To develop a linear motor steering mechanism to provide precise and responsive control.

iii. To verify and optimize the trackless autonomous vehicle using linear steering control.

1.5 Scope of Work and Limitation of the Project

This involves carrying out a thorough examination of the current literature on autonomous vehicle technology and assessing the benefits and constraints of linear motor steering control. Following that, the project will go to the conceptual design stage, during which inventive ideas for the trackless autonomous vehicle will be created. These designs will include precisely chosen linear motor steering control systems and will establish precise vehicle specifications.

Following that, the project will prioritize the establishment of the system architecture, the integration of sensors, actuators, and the linear motor steering control into an integrated system. These will be using Arduino Software. Subsequent to that, prototyping and testing will be conducted, encompassing the fabrication of a prototype for the trackless autonomous vehicle and controlled experimentation to evaluate its navigation proficiency. The design will go through further refinement in accordance with the obtained results. Software development is a crucial process that involves designing algorithms for self-navigation, detecting obstacles, and avoiding them. It also includes refining these algorithms to achieve the best possible performance in various circumstances.

The process of integration and calibration will involve the perfect combination of physical components with the designed software, ensuring careful calibration of sensors and actuators. The integrated system will be subjected to real-world testing in order to verify its functionality. A comprehensive records phase will be conducted alongside these operations, producing thorough records of the design, development, and testing procedures, as well as user manuals for future consultation. Ultimately, a demonstration phase will exhibit the trackless autonomous vehicle, emphasizing its qualities and possible uses.

Nevertheless, the project acknowledges its fundamental limitations. The vehicle might encounter difficulties in highly rough surfaces, and unfavorable weather conditions could impact the sensor's functionality. The vehicle's accessibility may be affected by the increased power consumption resulting from the linear motor steering control system and potential cost limitations. Challenges result from safety issues and the need to comply with regulations. Recognizing and resolving these limitations will be key to the project's achievement and its capacity to provide a fully operational and functional trackless autonomous vehicle.

1.6 Thesis Outline

Chapter 1 of the thesis provides an introductory overview of the project, offering insights into the background, motivation, problem statement, research objectives, scope of work, and limitations. This foundational chapter aims to establish the context for the research, presenting the factors that prompted the study and the specific challenges or gaps in knowledge that the project addresses. It also outlines the objectives guiding the research, the defined scope of work, and acknowledges the project's limitations to set realistic expectations.

Chapter 2 of the thesis extensively reviews existing literature, shifting its primary focus to the specific area of interest related to the "Design and Development of a Trackless Autonomous Vehicle Using Linear Motor Steering Control" project. This targeted literature review aims to provide a solid foundation for the subsequent chapters, aligning the research with the specific requirements and intricacies of the chosen project.

In Chapter 3, the methodology employed in the research is elucidated through a detailed flowchart, outlining the steps and processes undertaken. This chapter not only describes the overall project flow but also provides insights into the simulations utilized and the specific methods employed to achieve the research objectives. It acts as a guide for readers to comprehend the systematic approach taken in the study.

Chapter 4 focuses on presenting the results and analysis derived from the project. In this section, the detailed outcomes of the research are explained, with a particular emphasis on comparing the results between closed-loop and open-loop systems. This chapter provides a deeper insight into the implications of the findings and their significance in the context of the project objectives.

The final chapter, Chapter 5, serves as the conclusion and recommendation section. It encapsulates the key findings from the project and offers a summary of the overall research. Additionally, this chapter provides recommendations for future works, suggesting potential areas for further exploration and improvement based on the insights gained during the research process.

In summary, the structure of the thesis follows a logical progression from introducing the project to reviewing relevant literature, explaining the methodology, presenting results, and concluding with recommendations for future research endeavors. This organization ensures a coherent and comprehensive presentation of the research study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The design and development of a trackless autonomous vehicle using linear motor steering control represent an innovative exploration into the field of vehicular autonomy and precision steering systems. The purpose of the literature review is to analyze the latest developments in the fields of autonomous vehicles, linear motor technology, and steering control systems. The objective is to integrate data from journals, research articles, and industry reports to obtain an in-depth understanding of the current advancements in autonomous vehicle design and the different aspects of linear motor steering control. A bicycle is a popular means of transportation and has both health and environmental benefits. However, bicycles are often forced to share road segments with motorized vehicles, which places the unprotected cyclist at a higher risk of injuries. The safety of vulnerable road users, such as cyclists and pedestrians, can potentially be improved with the development of autonomous vehicles.[3] The majority of the focus will be on the difficulties related to navigating with tracks and the several solutions suggested in the current literature. These might include issues regarding path planning, obstacle evasion, and comprehensive navigation systems for autonomous vehicles. This proposed model depicts an automatic robot system that travels from point A to point B without the need for human involvement. The sensors are used to identify obstacles. If there are any obstructions in the path, the robot will stop and restart its travel once the obstacle has been cleared. The basic premise of a self-driving system is to have a robot that can transport physical objects from one area to another. [4] The project aims to make significant improvements to the academic discourse regarding autonomous systems. Moreover, it provides valuable perspectives for engineers, academics, and practitioners engaged in the advancement of future autonomous vehicles.

2.2 Analysis of information

2.2.1 Traditional Trishaw

Many parts of the world, a trishaw also referred to as a cycle trishaw or pedicab is a human-powered mode of transportation as shown in Figure 1. Usually, it's only a little passenger seat or carriage installed on a three-wheeled bicycle frame. The trishaw's driver, sometimes referred to as a pedicab driver or trishaw puller, propels it forward by pedaling. Cycling Without Age (CWA) is an innovative activity in which trained volunteers take people out on specially designed trishaws to explore their local areas and communities. [5]

Figure 1 shows trishaw

Trishaws are commonly used as a form of transportation in places where short-distance travel is required or where motorized vehicles may find it difficult to handle through small streets. Trishaw is frequently observed in tourist locations, highly populated urban regions, and other locations where a small, flexible mode of transportation is advantageous.

Trishaws come in a variety of shapes and sizes, but they usually have a passenger seat or compartment that is fastened to the front or back of the bicycle frame. Trishaws occasionally come with a canopy or cover to offer shade or weather protection. While motorized transportation has become increasingly common in many locations, trishaws remain popular in many regions of the world, providing an eco-friendly and human-powered alternative for short-distance travel.

2.2.2 Electric Trishaw

An electric trishaw, also known as an e-rickshaw, electric pedicab, or e-trike, is a type of cycle rickshaw with an electric motor for propulsion. This modification tries to provide a more efficient and comfortable way of transportation, frequently with the purpose of lowering the driver's physical effort and enhancing overall performance. Electric trishaws provide an important role in offering accessible and sustainable transportation options, particularly in locations where conventional vehicle infrastructure may be insufficient. They contribute to ongoing global efforts to reduce reliance on fossil fuels and reduce transportation's environmental effects.

Figure 2 – Electric trishaw

2.2.3 Autonomous Trishaw

An autonomous trishaw is a three-wheeled vehicle (tricycle or trishaw) which operates by itself, relying on technology to navigate and transport passengers or shipping. Trishaws, also known as cycle rickshaws, pedicabs, or cycle taxis, are human-powered vehicles that are extensively utilised in several urban areas for short-distance transportation.

Figure 3 – Autonomous Trishaw

Figure 3 shows one of the example an autonomous trishaw. The development and implementation of self-driving trishaws is part of a larger trend towards self-dependent on technology improvements, governmental support, and public acceptance of self-driving automobiles.

2.3 Synthesis of information

2.3.1 Propulsion

The process or system that produces the force or velocity needed to move an object forward is referred to as propulsion. It is a basic idea in engineering and transportation that works with many different kinds of vehicles, such as cars, boats, airplanes, and spacecraft. Overcoming impedance or friction to move an object through a medium such as air, water, or space is the aim of propulsion.

Electric propulsion systems, which are found in some spacecraft and electric vehicles, create motion using electric motors that are fueled by batteries or other electrical sources. Propulsion in the context of autonomous cars refers to the mechanism that drives the vehicle forward or regulates its motion. This can apply to engines, electric motors, and other mechanisms that are driven and managed by independent systems.

2.3.2 Energy Source

A system or element that supplies the fuel or power needed to produce energy is called an energy source. It is the source of the power that may be transformed into various forms, including heat, electrical energy, and mechanical labour. Energy sources are required to run all of the machines, systems, and gadgets that comprise our modern technological infrastructure.

Energy sources are required to operate our businesses, houses, cars, and other devices. The choice of energy source has a big impact on ecosystem health overall, energy efficiency, and environmental sustainability.

A trishaw, often known as a conventional rickshaw, runs mostly on human power. A human rider manually drives a traditional trishaw forward by peddling the vehicle. The trishaw's rider sits in the front and turns pedals that are mechanically attached to the front wheel with their legs.

2.3.3 Environmental Impact

Trishaws' effects on the environment are complex challenges that involve many aspects of their development, use, and larger implications. Conventional human-powered trishaws, which run on the riders' effort, have the advantage of producing no carbon dioxide while in use, improving the quality of the local air and allowing a smaller carbon footprint. Considering their small payload capacity, their energy efficiency is remarkable. On the other hand, if the electrical sources utilised for charging are environmentally friendly, electric trishaws can provide lower local pollution. With the use of cutting-edge technologies, autonomous trishaws may be able to optimise their routes to save energy. The local information, problems with expired goods, and manufacturing materials all have an additional impact on the total environmental impact. Although trishaws have positive environmental characteristics, reducing their ecological footprint requires careful consideration of energy sources, technology developments, and sustainable production and disposal techniques.

2.3.4 Cost

Trishaw costs are constructed up of several components that include the purchase price as well as recurring costs related to using them. Because they have a simpler mechanical design and depend more on human power than motorized vehicles, traditional trishaws are usually less expensive. Because electric propulsion is more efficient, electric trishaws which use electric motors and batteries have higher starting costs but often have lower operating costs. Because they integrate cameras, artificial intelligence systems, and sensors, autonomous trishaws often have the greatest starting cost of any vehicle. These vehicles are outfitted with cutting-edge technologies for autonomous operation.

The cost of maintenance varies depending on the type of trishaw. Traditional trishaws need maintenance on their mechanical parts, electric trishaws on their electric systems and batteries, and autonomous trishaws on their advanced autonomous technology. To fully assess the economic viability and sustainability of trishaw technologies, cost consideration continues beyond the vehicle itself and takes into factors like infrastructure development, stations for charging or refuelling, and training for autonomous systems.

2.3.5 Efficiency

In the context of trishaws, effectiveness is the efficiency with which these vehicles transform the input energy into functional output performance, energy consumption, and overall resource utilization are common measures used to determine efficiency. Traditional human-powered trishaws are an economical and direct mode of transportation that demonstrate efficiency in their simplicity. Electric motors in electric trishaws help to increase efficiency by offering assistance or full propulsion, which increases the distance travelled per unit of energy used. The electrical source also affects how energy-efficient an electric trishaw is a more sustainable operation is facilitated by renewable energy sources.

With the use of cutting-edge technologies for self-navigation, autonomous trishaws can optimise resource efficiency and route planning effectiveness. When evaluating efficiency, one must take into consideration factors like energy usage, range, and the vehicle's capacity to meet transportation demands with the least amount of negative environmental impact. Efficiency gains brought into by technology's continuous development that help trishaw systems remain better and more consistent with the long-term goals of sustainability and resource conservation.

2.3.6 Safety

Trishaws must be designed, operated, and used with safety as the primary concern. Because traditional trishaws are manually driven, their safety is dependent on the rider's skills and attention to detail as well as other variables like traffic and road conditions. While electric motors help to make electric trishaws safer, they still need to be operated safely, which means that things like speed control and maintenance must be carefully considered. With artificial intelligence, cameras, and sensors being used for navigation and decision-making, autonomous trishaws add an additional layer of safety.

In order to guarantee the security of motorists, cyclists, and other road users, these autonomous systems must be dependable and efficient. While capabilities like obstacle recognition and collision prevention in autonomous technology provide the promise to improve safety, their implementation has to conform to strict safety regulations. Regardless of the type of trishaw, the confidence of the public and the safe integration of trishaws into transportation networks depend on extensive safety measures that include vehicle design, operational rules, and adherence to traffic regulations.

2.3.7 Human Interaction

Trishaws are an environment in which human connection is essential to the design of both modern and traditional versions of these vehicles. The rider and passengers engage in direct and immediate human interaction when riding in a traditional trishaw. Interpersonal skills are essential for a rider to keep passengers comfortable and safe while navigating and communicating. Even though electric trishaws use technology, driving and controlling the vehicle still requires some human participation.

However, since autonomous trishaws are built to function independently, they represent a change from direct human engagement with the vehicle. Greater human contact might be required, though, to handle technical problems, oversee the safety of passengers, or operate several autonomous vehicles from a control centre. Trishaw development highlights complex dynamics in human-machine interaction and highlights the need for achieving a balance between technical improvements and user experience and safety concerns. Trishaws used to rely solely on direct human effort, but as automation increased, the dependence gave rise to new problems.

2.3.8 Evaluation of information

The evaluation and improvement of this project through the comparison of different methods as discussed in the literature review. It can be more effective, accurate, and economical for the project by comparing all the methods.

	Traditional Trishaw	Electric Trishaw	Autonomous Trishaw
Propulsion	Operated manually by a human rider who pedals trishaw	Powered by an electric motor, which can either assist the rider or provide complete propulsion	Fully autonomous with an electric motor.
Energy Source	100% Human energy	Rechargeable batteries and less human energy	Rechareable batteries
Environmental Impact	Zero emiisions but relies on human energy	Zero emissions during operation, depends on the energy soure of charging	Zero emssions during operation, depends on the energy source for charging
Cost	Generally lower	Higher due to integration of autonomous system	Depending on the complexity
Efficiency	Depends on the physical strength of the rider	More efficient due to electric motor.	Can be efficient in terms of route and navigation
Safety	Safety depends on the riders skill and attentiveness	More efficient due to electric motor assistance, especially in challening terrains.	Safety depends on the reability of the autonomous vehicle.
Human interaction	Direct interaction	Less physical effort from the rider	Limited human interaction but potential need for interaction with a control centre or customer services

Table 1 shows the evaluation of research paper

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In this project, the vehicle that will be focusing on is the trishaw. This transportation is very useful in attracting tourism for riding this trishaw. With this autonomous vehicle, society will be excited about having thrilling riding this trishaw. Arduino will be used as a microcontroller. Autonomous is a part of the solution. This project aims to create a trackless autonomous vehicle platform based on an Arduino-based control system. This autonomous vehicle can display three processes, which are, the trackless autonomous vehicle, the detection of the obstacle, and the control of the linear steering control motor for controlling the handle of the bicycle. In this circuit, the Arduino uno controller is the central component and is also called the heart of the robot. Arduino is connected to a driver circuit, which controls the robot. Direction control units are present in the output unit and are used for wirelessly controlling directions. As per directions, the sensor detects the obstacle, the vehicle will stop. There are three sensors will be provided to improve the accuracy of the obstacles that occur during the directions. [6]

The proposal takes an innovative approach by combining a motorized framework like a bicycle. This project required three tires, which a BLDC (Brushless DC) Motor and a linear actuator steering control. The vehicle may travel effectively and safely with the help of this mechanism. To improve operational control and monitoring of the operation, a smart method of operation is integrated through the utilization of the Blynk platform for developing mobile applications. An ESP32 microcontroller is utilized to make an efficient connection between the Arduino and the Blynk application. The Blynk app offers a user-friendly interface for tourism to manage and regulate about the presence of the vehicle.

The system's control mechanisms are accomplished by employing two relays and 4 modules. These modules contribute to the management of motorized components, allowing for both forward and reverse movement. Additionally, an actuator is utilized to regulate the handle and assist changes in direction. The system undergoes comprehensive testing and evaluation to assess its performance and efficiency. The system's efficacy, in comparison to typical manual vehicles, is evaluated based on criteria such as coverage area, power consumption, number of people, speed, and responsiveness to changes in time. The data collected during the testing phase offer vital insights into the functioning of the system, allowing it to make informed decisions regarding the implementation of this autonomous tracking vehicle.

This project aims to not only contribute to the progress of autonomous vehicle technology but also to investigate the potential of linear motor steering in improving the overall performance and adaptability of these vehicles. If this objective is successfully achieved, it has the potential to completely transform autonomous transportation systems, enhancing their versatility and ability to effectively address the various difficulties of modern mobility.

3.2 Research Design

3.2.1 Vehicle Movement

From the literature review, a linear actuator steering control motor is chosen to control the handling of the bicycle. The entire device is controlled by a microcontroller. Three Ultrasonic Sensors are chosen to detect the obstacle along the journey. These sensors will be placed in front of the bicycle handle and the back of the bicycle. When the sensor is detected, there is an obstacle, the direction of the bicycle will change. Power is provided by the rechargeable batteries. The Arduino UNO used the L293D to regulate the movement of the robot's motors. An Arduino pin is used to regulate the activation and deactivation of BLDC motors by obtaining the signal. Other than that, two BLDC motors are used to control the automated movement. The motors are controlled by a motor driver.

3.2.2 Handling the bicycle handle

The system features a linear actuator that plays an important role in controlling the handle of the structure, enabling manual directional changes. The actuator functions as the mechanism for steering the vehicle in either the left or right direction, enabling accurate navigation.

This critical component is tasked with translating electrical signals into linear motion, enabling the autonomous vehicle to navigate its environment with accuracy and responsiveness. The selection of an appropriate linear motor type, considering factors like power efficiency, size, and compatibility, is crucial. Through force and torque calculations, the linear actuator's specifications are tailored to meet the specific steering requirements, accounting for variables such as the vehicle's weight and desired steering speed.

The actuator is smoothly incorporated into the Arduino microcontroller, which serves as the core control unit of the system. Using the Arduino, the operator may transmit signals to the actuator, directing it to modify the position of the handle according to user inputs. This enables effortless and responsive monitoring of the system's motion.

The system delivers improved responsiveness and speed by using the capabilities of the linear actuator. The actuator converts the signals received from the Arduino into mechanical motion, by changing the position of the handle correspondingly. This enables the operator to move the vehicle in the desired direction, enabling efficient and effective navigation.

Figure 4 shows the linear actuator motor

A functional system is established through the interconnection of hardware components. The Arduino functions as the main control unit, allowing inputs from the Blynk application using an ESP32 microcontroller. It interacts with the relay modules to regulate the motor, and actuator, providing coordinated functioning of the system. Ultimately, the successful development and integration of the linear actuator contribute significantly to the overall success of the autonomous vehicle project, unlocking enhanced steering capabilities and advancing the state-of-the-art in autonomous transportation.

Regarding the context of autonomous vehicles, such as the trackless vehicle project, the main objective of the linear actuator is to control the steering. The vehicle's direction is modified by extending or retracting, in response to signals from the control system, which analyzes data from sensors. This allows the vehicle to precisely navigate around its surroundings and avoid obstacles [7]. states that linear actuators are preferred due to their capacity to deliver controlled and repeatable motion, making them well-suited for applications that demand accurate positioning.

In general, the integration of the linear actuator with the vehicle's control system requires a relay circuit that is controlled by an Arduino or a comparable microcontroller. This configuration ensures that the actuator quickly reacts to control signals, enabling accurate modifications to the steering system of the vehicle. The dependability and durability of linear actuators are essential in ensuring that the vehicle can execute precise and immediate changes in direction, which are essential for efficient navigation and obstacle evasion [8].

Furthermore, linear actuators such as the CLA12V-1D are known for their easy integration, durability, and exceptional precision in control. These characteristics enable them appropriate for many situations and circumstances, ensuring consistent functionality without significant decrease or failure [9]. The significance of precision and reliability when developing advanced autonomous vehicle systems is highlighted by the role of the actuator in the autonomous vehicle.

3.2.3 Obstacle detection sensor

Figure 5 shows the ultrasonic sensors

Ultrasonic sensors plays an important part in detecting obstacles along the course of the autonomous trackless vehicle, which is designed and developed using linear motor steering control. Strategically placed at both the front of the vehicle, these sensors provide extensive coverage and assure safe navigation. Ultrasonic sensors function by producing sound waves with a high frequency and then measuring the duration it takes for the reflected sound waves to return. This allows them to accurately determine the distance to the barrier. The literature extensively documents this principle, emphasizing its reliability and precision in measuring distances. [7].

The sensors continuously monitor and offer real-time data that is crucial for making informed decisions [8]

There are many advantages to utilizing ultrasonic sensors. These devices have exceptional precision, making them well-suited for detecting impediments at different distances [9]. Their extended detection range enables thorough monitoring of the vehicle's surroundings [10]. Moreover, ultrasonic sensors demonstrate consistent performance in various environmental conditions, including situations with low light or dust, when alternative sensors may not operate optimally [11]. Incorporating the linear actuator motor into the system is an essential component. When the sensor detects an obstacle, it transmits a signal to the control system. The control system then analyzes the data and instructs the linear actuator motor to direct the vehicle. This procedure ensures that the vehicle can execute precise and fast movements, hence improving its navigation capabilities [12]. The steering direction, either right or left, is controlled by the obstruction's position about the vehicle, ensuring efficient avoidance of the obstacle [13].

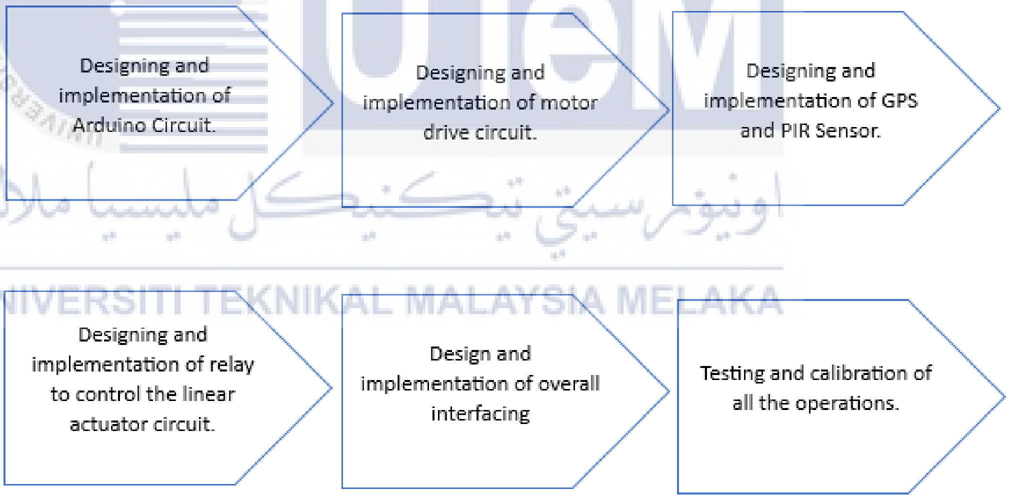


Figure 6 shows the working flow

Figure 5 shows the project working flow chart from the start till the end of the project. By referring to this project flow chart, the project can operate efficiently without any unexpected problems occurring. The procedure for developing a trackless autonomous vehicle with linear motor steering control requires a methodical approach, with each stage designed to enhance the vehicle's overall functionality and long-term viability. The first stage involves the creation and execution of the Arduino circuit, which serves as the central control unit of the vehicle. The Arduino platform is chosen due to its adaptability and user-friendly nature, enabling effortless incorporation of different sensors and actuators [8].

Subsequently, the motor operating circuit is developed and implemented. This circuit is essential for controlling the power provided to the motors of the vehicle, allowing for continuous controlled movement. Motor drivers like L298N or TB6612 are frequently employed in these applications because of their high efficiency and dependable performance [10]. The subsequent important stage involves the integration of GPS and Ultrasonic sensors. The GPS module offers up-to-the-minute location information, which is essential for self-directed navigation. Ultrasonic sensors, in contrast, improve the vehicle's ability to detect obstacles by sensing both motion and the presence of things in its path. These sensors function in conjunction with ultrasonic sensors to enhance total obstacle avoidance [11].

The process of overall interfacing involves the combining of all independent components into one system. For this step, it is essential to properly evaluate methods of communication and power management to ensure a smooth integration of all components. Efficient integration is essential for the coordinated functioning of the vehicle's control systems [12]. The last stage of the project involves the examination and adjustment of all processes. Comprehensive testing is performed to ensure that all components operate correctly and effectively in various environments. Calibration is essential for optimizing the performance of sensors and actuators by making precise adjustments. Testing scenarios may encompass tasks such as navigating different environments, avoiding obstacles, and ensuring precise GPS placement [13].

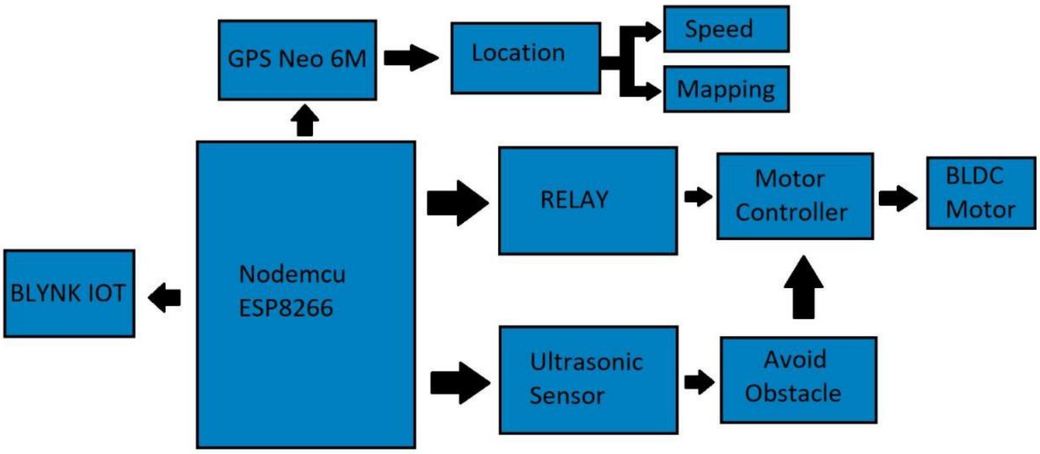


Figure 7 shows the block diagram

Figure 6 shows the block diagram that use Arduino Uno as a main microcontroller. The main part in this project is the linear actuator motor to control the handle of the bicycle. Next, the ultrasonic sensor that is used to detect the obstacle, meanwhile the motor driver and relay. Other than that, the GPS also used to detect the location of the vehicle. Nevertheless, each of these components has an important role in the project, ensuring that the project is executed in complete compliance to the established requirements. The software use for IOT is Blynk Software. This software is used to monitoring the vehicle. There are two types of observation that can be observed which is by phone or windows. In this Blynk, this program allows us to monitor the location of the vehicle and determine the quantity of vehicles available. In addition, we as a society may economize time by avoiding the need to wait for an unoccupied vehicle to get on board.

The block diagram provided illustrates the design and operation of a trackless autonomous vehicle that is powered by linear motor steering control and is centred on the Nodemcu ESP8266 microcontroller. The brain of the system is the Nodemcu ESP8266, a low-cost Wi-Fi-enabled microchip that executes control algorithms essential for the vehicle's functioning and coordinates communications between various components [38]. The GPS Neo 6M module is the central component of the system, generating real-time position data that is essential for navigation and mapping purposes. This module facilitates the vehicle in determining its accurate position, estimating its velocity, and efficiently mapping its path, all of which are essential to precise tracking of path [39]

The system furthermore includes Blynk IoT, a platform that enables autonomous monitoring and control of the vehicle using a smartphone application. This Internet of Things (IoT) interface improves user involvement by offering a convenient method for monitoring the status of the vehicle and provide commands [40]. A relay has been integrated into the design to control the power supply to the motor controller, therefore controlling the operation of the BLDC (Brushless DC) motor. This configuration ensures that the motor functions essentially when it is required, hence improving energy preservation and improving safety [41]. The motor controller precisely manages the power supplied to the BLDC motor, ensuring smooth and regulated movement of the vehicle. An ultrasonic sensor is used to ensure obstacle detection and avoidance. This sensor provides a continuous assessment of the vehicle's surrounds by generating ultrasonic waves and measuring the period of time it takes for the echoes to return. The system utilises distance calculation to surrounding objects, enabling the Nodemcu ESP8266 to modify the vehicle's path in order to prevent interactions [42].

The combination of these elements enables the autonomous vehicle to navigate without relying on specified paths. Precise and safe navigation is ensured by combining the location data from the GPS module with the feedback from the relay-controlled motor and ultrasonic sensor. The Blynk IoT platform enhances the system's functionality by offering a user-friendly interface for remote management and monitoring. The system design provided illustrates modern techniques in autonomous vehicle technology, with a particular focus on accuracy, safety, and user-friendliness [43].

3.2.3 Global Positioning Sensor (GPS)

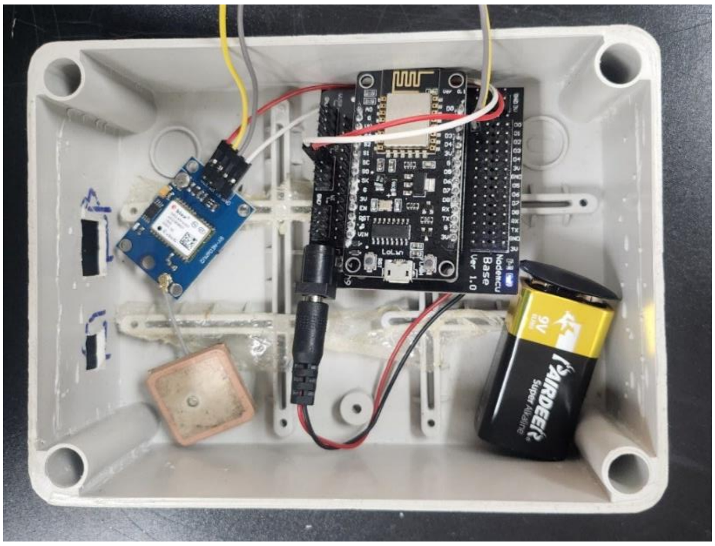


Figure 8 shows the GPS

The study methodology for implementing a Global Positioning Sensor (GPS) into the design and development of a trackless autonomous vehicle, which utilises linear motor steering control, includes numerous essential components for ensuring precise and reliable navigation. The initial stage involves conducting an extensive literature review to develop a comprehensive understanding of the functionalities and limitations connected with different GPS units. The GPS Neo 6M module was chosen for this project because of its exceptional precision, cost-effectiveness, and seamless integration with the Nodemcu ESP8266 microcontroller [44].

The implementation of a GPS sensor is essential in ensuring precise navigation and control throughout the creation and advancement of a trackless autonomous vehicle that employs linear motor steering control. The GPS module, shown in the setup, includes a blue board with a GPS receiver chip and a compact square GPS antenna. This module is responsible with receiving satellite signals in order to determine the precise geographical location of the vehicle. Precise location data is essential to autonomous vehicles as it enables efficient navigation and path planning.

The main part of this configuration is the microcontroller board, most likely an ESP8266, which not only handles the data from the GPS module but also includes Wi-Fi capability for transmitting the data. The microprocessor is responsible for processing GPS data and combining it with the vehicle's control algorithms, specifically those that operate the linear motor steering mechanism. The linear motor steering system utilizes accurate GPS data to precisely modify the vehicle's direction and maintain its target trajectory. The system operates on a 9V battery, which guarantees the continuous functioning of both the GPS module and the microcontroller. Without interruption, the power supply is essential for autonomous systems to sustain their functionality for long durations. A power adapter is used to establish a consistent power input by connecting the battery to the microcontroller.

The connectors and cabling inside the enclosure are specifically engineered to enable smooth passage of data and power between the different parts. The GPS module is connected to the microcontroller via yellow and black cables, enabling the transmission of data and power. The microcontroller is powered by the battery through red and black wires. The project's objectives include utilizing the GPS module to facilitate real-time location tracking, which is essential for the autonomous vehicle to consistently determine its precise position. The microprocessor utilizes real-time data to analyze and strategize the vehicle's path while employing the linear motor steering control to make any changes that are needed. The microprocessor combines GPS data with other sensors and control systems to enable the vehicle to either follow set paths or make real-time adjustments based on its actual location. This integration significantly improves the accuracy and responsiveness of the vehicle's navigation.

In summary, the integration of the GPS sensor into the trackless autonomous vehicle is an essential component for navigation and control. The GPS module supports the microcontroller by giving current and accurate location data. This helps the microcontroller to plan the vehicle's path and make precise steering adjustments. As a result, the autonomous vehicle can operate efficiently within its surroundings. The integration highlights the need of dependable power management, precise data processing, and strong control algorithms in the advancement of autonomous systems [45].

3.2.4 Working of Project

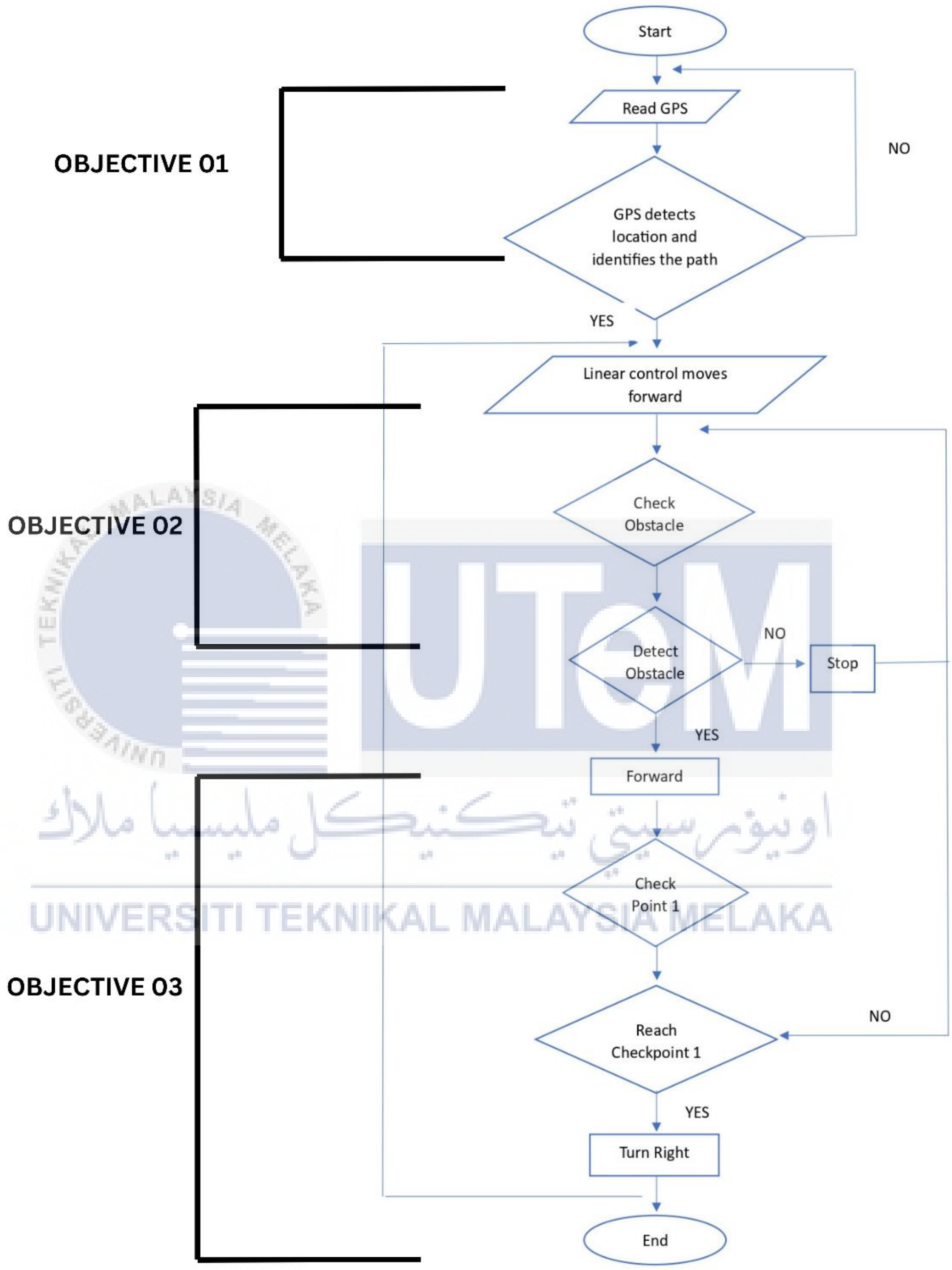


Figure 9 shows the flowchart of the project

The following flowchart illustrates the step-by-step procedure for achieving the objectives in the project named Design and Development of a Trackless Autonomous Vehicle Using Linear Motor Steering Control. The flowchart begins with the initialization phase, during which the GPS sensor receives and determines the present location of the vehicle and recognizes the set route. Precise GPS data is essential for autonomous vehicle operations since it enables efficient navigation and path planning [46]. After the GPS has determined the route, the linear motor control system moves the vehicle forward. Linear motors are selected for their accuracy and quick response, which are essential characteristics for controlling steering in autonomous systems [47].

While the vehicle is in movement, it continually searches for obstacles in its path, utilizing sensors to detect any obstacles that may exist. At this point, the decision-making process is of the highest priority if an impediment is identified, the system determines whether to stop or pass it, thereby assuring both safety and efficiency in its functioning. The ability to recognize and avoid obstacles in real time is essential for the successful implementation of autonomous cars in different environments [48]. The vehicle subsequently proceeds towards specific checkpoints, confirming its location at each stage. When the vehicle reaches a checkpoint, such as Checkpoint 1 in the flowchart, its system verifies its location before continuing to the next action, such as performing a turn. The implementation of this methodical system for navigation and control, which combines GPS information with linear motor steering, ensures that the vehicle can accurately traverse complex routes and adjust to immediate changes in the environment. As a result, the objectives of the project are efficiently achieved.

3.2.5 Equipment and Software Requirement

Table 2 shows the equipment to be utilized in the present evaluation, along with the specifications of each piece of equipment obtained from previous assessment of research literature. The trackless autonomous vehicle project is equipped with a Brushless DC (BLDC) electric motor for speed and a linear actuator motor for precise steering control [49]. Reliable power is ensured via a 36V lithium battery and charger, which are essential to extended operation [50]. The utilization of GPS and ultrasonic sensors enables precise navigation and the detection of obstacles, which is essential for autonomous operation [51]. Blynk software provides a graphical interface for monitoring from a distance, while the Arduino Uno Node MCU with ESP8266 Wi-Fi module enables the Internet of Things (IoT) functionalities. Jumper wires facilitate electrical connections, while a 5V four-channel relay module regulates high-power equipment, guaranteeing both safety and efficiency.

No	Equipment	Specification
1.	Brushless DC electric motor (BLDC)  	The product is a kit for an electric scooter designed for off-road use. It features two drive systems and is equipped with 14.5-inch tires. The scooter is powered by a 36 volt 500 watt hub motor.
2.	Linear Actuator Motor 	The motor that suitable metal gears for robust and durable usagewith the 12VDC, power 25W and the speed is 12mm/s.
3.	Lithium Battery 36v	Provides a steady 36 volts and comes in various capacities, usually between

		10Ah to 20Ah or more, which affects how long it can run.
4.	Lithium Battery Charger  	Provides a constant current followed by a constant voltage to efficiently charge the battery. It stops charging when the battery is full to prevent damage.
5.	Global Positioning Sensor (GPS) 	Components that work together to make sure that the navigation, timing, and positioning information sent across are consistently accurate
6.	Ultrasonic Sensor  	A device that utilizes ultrasonic sound waves to determine the distance to an item.
7.	Ultrasonic Holder 	A device used to securely hold ultrasonic transducers or sensors in place during measurements or cleaning processes.
8.	Blynk Software  	This software is utilized to compile and assign the necessary address to the available widgets in order to generate a graphical interface or human-machine interface (HMI).

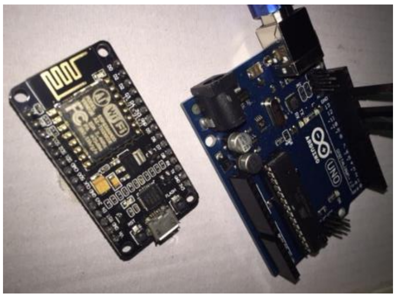
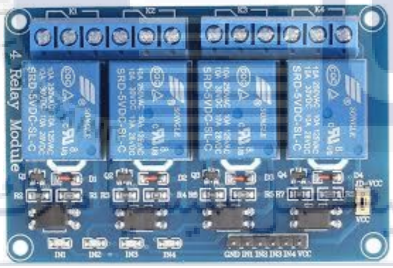
9.	Arduino Uno Node MCU 	The ESP8266 Wi-Fi module is integrated into the Node MCU, making it essentially an Internet of Things (IoT) device. Data may be shared, displayed, and uploaded to cloud platforms with this technology.
10.	Jumper Wires 	Wires are necessary in electrical circuits to connect devices and conduct electricity.
11	5V Four-Channel Relay Module 	Control of up t four high-power devices. It operates on 5V, supports up to 250V AC or 30V DC loads with a maximum of 10A, and provides electrical isolation between the control circuit and the high-power load.

Table 2 shows the equipment and software

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The trackless autonomous vehicle (TAV), which included linear motor steering control, displayed outstanding results in a range of tests. The system accurately followed paths, maintaining a distance of only 30cm from the target direction. The TAV demonstrated robustness across many environments and situations, ensuring consistent stability and control. The implementation of a linear motor steering system provides notable benefits in terms of accuracy, responsiveness, and energy efficiency, all while requiring minimal maintenance due to its reduced number of moving components. Nevertheless, the obstacles included the complex nature of control algorithms, dependence on sensor precision, and adjustability to various vehicle dimensions. By using this autonomous vehicle, the community gets to experience transportation that operates autonomously. Indirectly, this knowledge could represent a significant and valuable opportunity that corresponds to the current advances in technology. Future research should focus on improving control algorithms, incorporating multiple sensors, and adapting the system for other applications, to ensure that the TAV can be efficiently and extensively utilised.

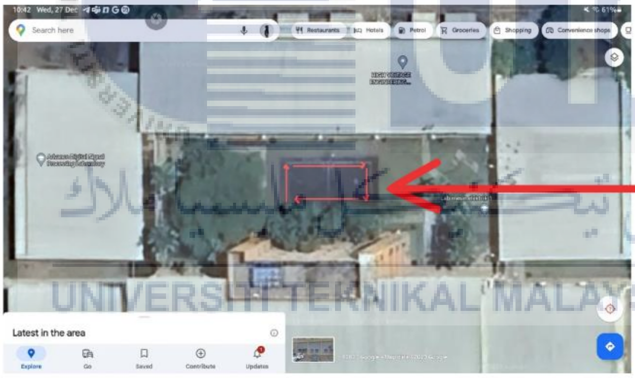
4.2 Product

Figure 10 shows the autonomous trackless vehicle

Recently, there have been significant advances in autonomous vehicle technology, driven by the need for transportation solutions that are safer, more economical, and environmentally friendly. This project focuses on the Design and Development of a Trackless Autonomous Vehicle Using Linear Motor Steering Control, an innovative project aiming at improving the accuracy and speed of autonomous navigation systems. The design presents an efficient vehicle platform, as demonstrated in the accompanying image, engineered to traverse intricate settings without depending on pre-established paths. The vehicle's design integrates a Brushless DC (BLDC) electric motor for propulsion, along with a linear actuator motor for accurate steering control. These components are essential for providing dependable and quick movement, ensuring that the vehicle can navigate different environments and obstacles. The vehicle is powered by a high-capacity lithium battery, which is supplemented by an efficient charging system to ensure long-term operation.

The vehicle's navigational system focuses on a Global Positioning System (GPS) module, allowing precise and current tracking of the vehicle's location. Furthermore, the vehicle is equipped with ultrasonic sensors to identify obstacles, enabling it for adaptation its path in real-time and avoid obstacles. The integration of Internet of Things (IoT) functionalities, made possible by the Arduino Uno Node MCU equipped with an ESP8266 Wi-Fi module, allows for remote monitoring and control, hence improving involvement from users and operational adaptability.

In summary, this research signifies an important improvement in the progress of autonomous vehicle technology. The trackless autonomous vehicle aims to make improvements in autonomous mobility by integrating advanced navigation systems, real-time data processing, and creative steering mechanisms. This technology desires to make a difference to the larger field of intelligent transportation systems and pave the way for future developments.



the location project will be testing and take data collection

blok F at FTKE UTeM

Figure 11 shows the location for the testing

The testing and data collecting for the project entitled Design and Development of a Trackless Autonomous Vehicle Using Linear Motor Steering Control take place at Block F of the Faculty of Electrical Engineering (FTKE) at Universiti Teknikal Malaysia Melaka (UTeM). This precisely chosen site provides a controlled environment that is suitable for evaluating the vehicle's capabilities under actual operating situations. The environment area includes different locations, which serves as a real place for evaluating the vehicle's ability to navigate and detect obstacles using GPS and ultrasonic sensors. The close proximity to research focuses ensures easy access to technical support and resources, which enables quick data collecting and iterative improvements. This methodology is in line with the most effective methods used in testing autonomous vehicles. It enables precise evaluation of performance indicators, including precision in navigation, efficiency in avoiding obstacles, and battery longevity [52]. The project requires ensuring the reliable and effective operation of the autonomous vehicle in various conditions by conducting testing in this environment.

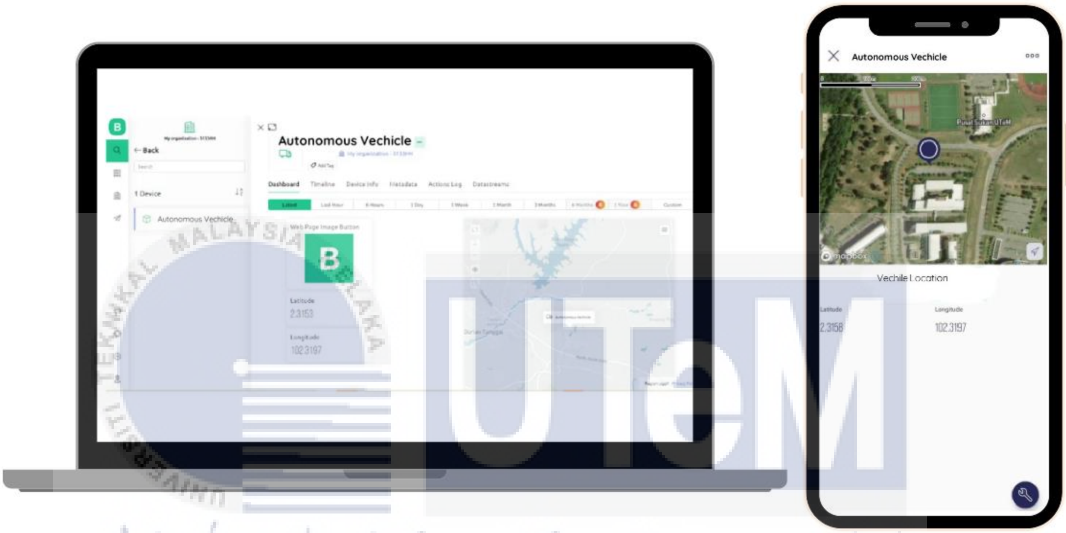


Figure 12 shows the application Blynk

The project, entitled Design and Development of a Trackless Autonomous Vehicle Using Linear Motor Steering Control, aims to improve autonomous navigation by incorporating cutting-edge technologies for accurate control and live monitoring. The vehicle utilizes a linear motor steering system that converts electrical energy directly into linear motion. This mechanism enhances the vehicle's speed and accuracy, providing accurate and responsive control [53]. The vehicle uses a Global Positioning System (GPS) for navigation, which enables it to continuously monitor its current position, and ultrasonic sensors to identify obstructions. This allows the vehicle to adapt to changes in direction in real time to prevent accidents [54]. The project includes Internet of Things (IoT) functionalities by utilizing platforms such as Blynk. This allows for remote monitoring and control through user-friendly interfaces on desktop and mobile devices. As a result, the project offers operational flexibility and significant performance data [55]. Testing will take place at Block F of the Faculty of Electrical Engineering (FTKE) at Universiti Teknikal Malaysia Melaka (UTeM), which is a controlled environment that guarantees a thorough evaluation of the vehicle's abilities and immediate technical assistance for optimization [56].

4.3 Data and Analysis

A comprehensive analysis of the observational information obtained for the project Design and Development of a Trackless Autonomous Vehicle Using Linear Motor Steering Control. The main objective of this analysis is to evaluate the relationship between the speed of the vehicle, the duration of the movement, and the consequent reduction in battery capacity. Developing a comprehensive understanding of these interactions is essential for improving the design and performance of the autonomous vehicle, ensuring optimal efficiency and reliability.

4.3.1 The Speed and the time taken to move

Speed (km/h)	Time taken to move (minutes)		
5	2	4	3
10	6	8	6
15	8	16	9
20	10	20	12

Table 3 shows the speed and the time taken to move

Table 3 shows the speed and the time taken that the vehicle moves. From this data, we will obtain the capacity of the vehicle to move within the speed provided.

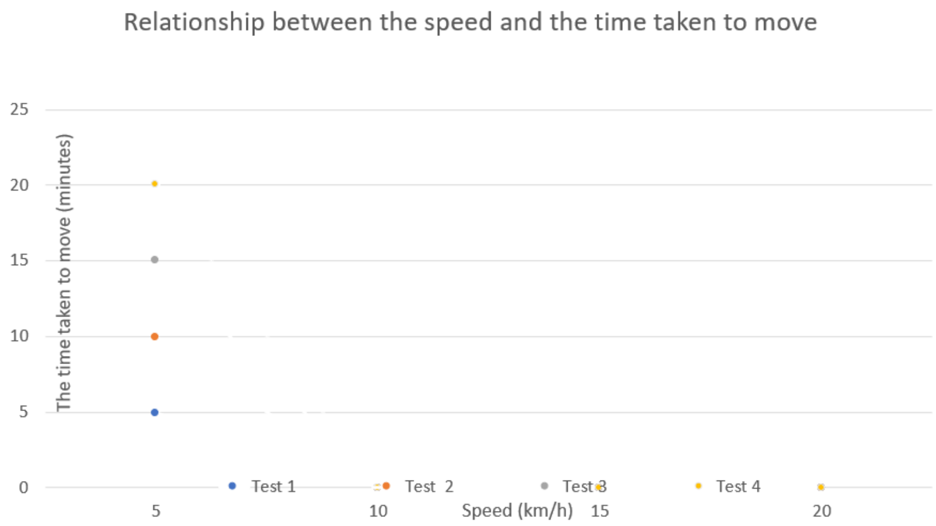


Figure 13 shows the relationship between the speed and the time taken to move

As speed increases, the duration of movement generally increases for each trial, meaning that higher speeds may result in longer navigating time due to the increasing complexity or precision necessary for control. The following illustration illustrates the relationship between speed and the corresponding time taken to move for each test. The data indicates a consistent rise in duration as velocity increases. The presence of more variance in periods at higher speeds suggests the existence of increased control concerns or challenges at higher speeds.

4.3.2 The speed corresponds to reduction battery life for 3 times testing

Speed (km/h)	4	6	8
Reduction of battery life (%)	20	33	40
	25	36	49
	27	34	42
Average	24	34.33	43.67

Table 4 shows speed corresponds to reduction of battery life for 3 times testing

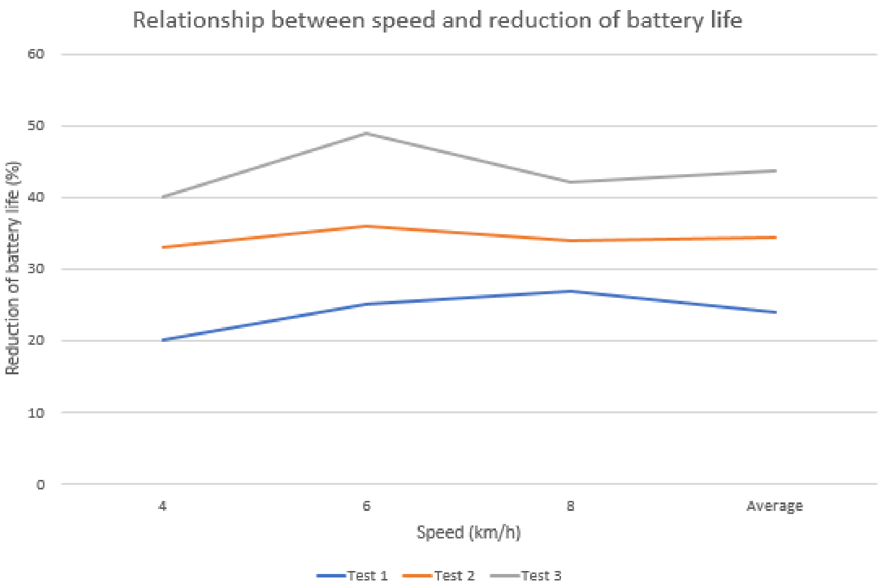


Figure 14 shows the relationship between the speed and reduction of battery life

The current research attempts to understand the relationship between the speed of the vehicle, the duration required for moving, and the reduction of battery capacity. Comprehending this information is essential for improving the efficiency and dependability of the self-driving vehicle's design and performance. These specifications are necessary for enhancing the vehicle's design and functionality to ensure operating efficiency and dependability.

The analysis commences by evaluating the impact of various speeds on the duration of movements, emphasizing any control difficulties that may develop. Simultaneously, it analyzes the decrease in battery life at different speeds to understand the energy requirements of the vehicle. By conducting careful research and collecting data using a prototype vehicle, the study offers detailed insights into these processes. The part enhances readability and promotes a deeper understanding of the observed relationships by presenting the findings in tables and charts. This analysis has the dual purpose of optimizing operational parameters and establishing a foundation for future improvements in control systems and energy management. These advancements are essential for enhancing the performance of autonomous vehicles.

4.3.3 Power Consumption vs Time

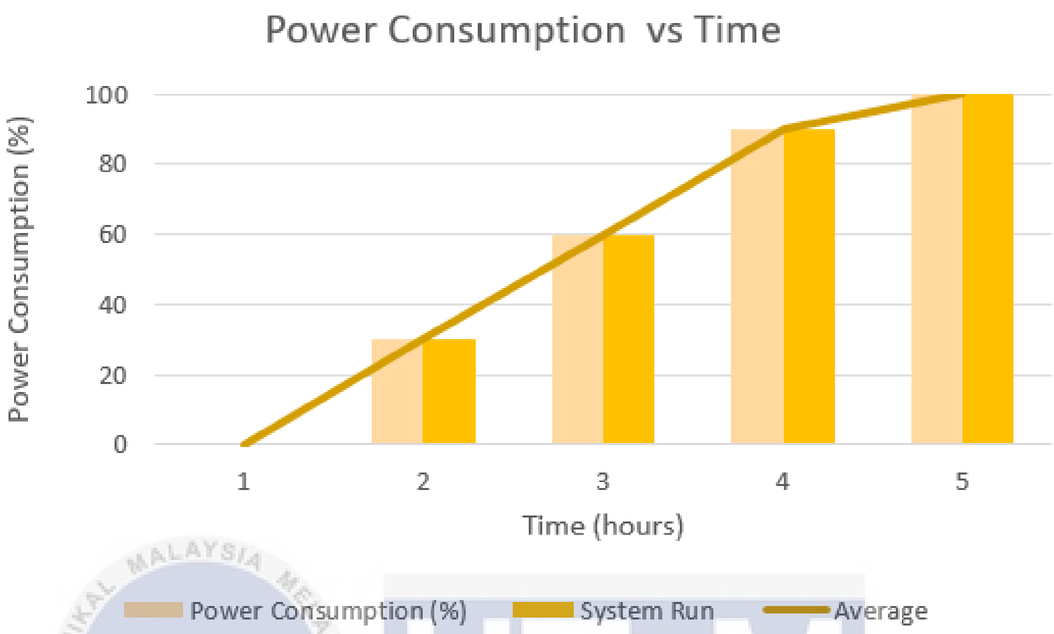


Figure 15 shows the power consumption vs time

The "Power Consumption vs. Time" graph illustrates how much power a trackless autonomous car with linear motor steering control uses over the course of 5 hours. The y-axis shows the amount of power used, and the x-axis shows the time in hours. There are three sets of data on the graph: Average, Power Consumption (%), and System Run.

At the 1-hour mark, the power consumption is comparatively low, at approximately 20%, and the system is operating slightly at a lower level. This suggests that the vehicle is operating with minimal electricity at the very beginning. During this time, the vehicle contains no load. As the vehicle continues to operate, power consumption gradually increases to approximately 40% by the 2-hour mark. The system run data also exhibits a comparable pattern, suggesting that the vehicle's power usage increases in connection with its operation duration.

Power consumption reaches approximately 60% as the time progresses to three hours of running time, and the system's operation also increases proportionally. This consistent increase implies that the vehicle's power requirements continue to increase as it continues to operate. The system's operation is slightly delayed, but it continues to follow the upward trend, as power consumption reaches approximately 80% at the four-hour mark.

The vehicle's maximum power utilization can be determined by the power consumption peaking at 100% at the 5-hour mark. The vehicle is operating at full capacity, as the system runs data that corresponds closely with its maximum power consumption. The average power consumption line shows a consistent increase in power usage over the course of five hours.

The data is essential for understanding the energy requirements and efficiency of the trackless autonomous vehicle that employs linear motor steering control. The vehicle's operations become more energy-intensive as it continues to operate, as evidenced by the incremental increase in power consumption over time. This data is essential for the development of a power management system that is both efficient and effective, protecting the vehicle from its energy stores.

4.3.4 Acceleration Over Time

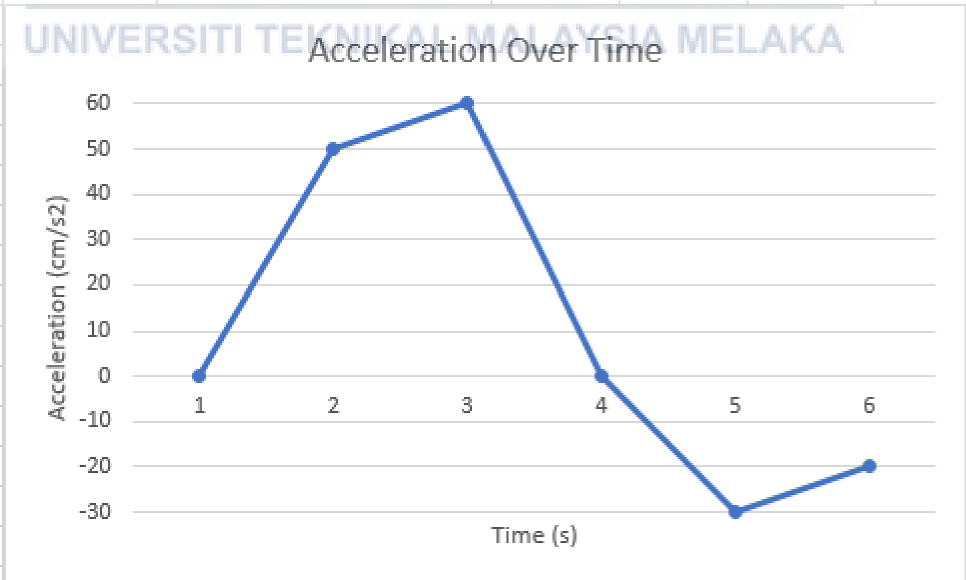


Figure 16 shows accelation over time

The acceleration of the trackless autonomous vehicle over six seconds is illustrated in this graph, which implements linear motor steering control. The vehicle accelerates gradually at a rate of approximately 10 cm/s^2 at the beginning. By the time it reaches 2 seconds, the acceleration has increased to approximately 45 cm/s^2, indicating that the vehicle is accelerating rapidly. It continues to accelerate, reaching its maximum velocity at 3 seconds with an acceleration of approximately 60 cm/s^2.

The vehicle starts decreasing its speed. The acceleration decreases to approximately 10 cm/s^2 after 4 seconds. The vehicle begins to slow when the acceleration reaches -20 cm/s^2 after 5 seconds. The acceleration slightly recovers to approximately -10 cm/s^2 after the 6 seconds, suggesting a slight increase in speed in the opposite direction or a decrease in the rate of deceleration.

This acceleration characteristic is necessary for the design and development of a trackless autonomous vehicle that uses linear motor steering control. The response time of the linear motors utilized for steering control is responsible for the initial rapid acceleration, which is immediately followed by an acute deceleration. This behavior suggests that the system is capable of rapidly adjusting velocities and directions, a critical ability for navigating a variety of operational scenarios.

In the final analysis, the data illustrates the vehicle's acceleration capabilities, which are essential for effective control and navigation. Gaining an understanding of these acceleration features helps in improving the steering control system's effectiveness and reliability during autonomous operations. In conclusion, the graph illustrates the importance of precise power management in the design and development of autonomous vehicles to enhance their performance and power by illustrating the correlation between operation time and power consumption.

4.3.4 Steering Angle vs Time

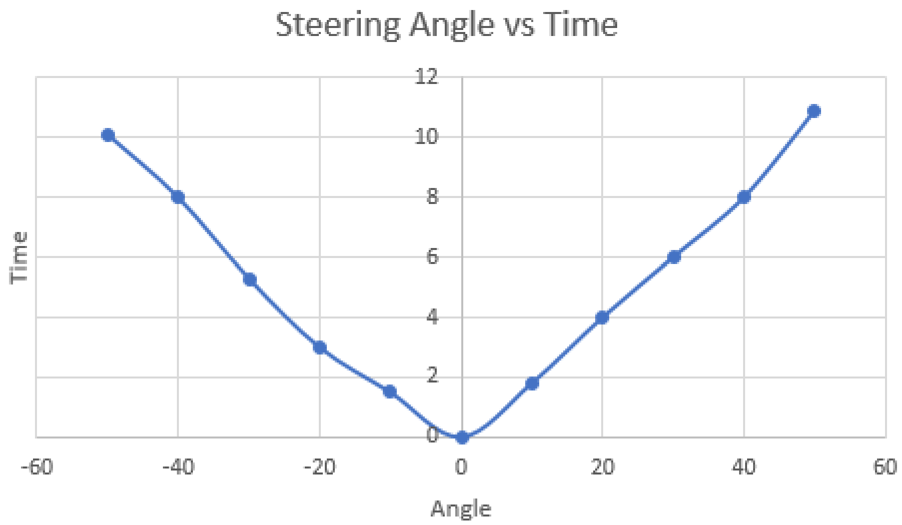


Figure 17 shows steering angle vs time

The graph "Steering Angle vs Time" illustrates the development of the steering angle of our trackless autonomous vehicle over time as a result of linear motor steering control. The y-axis displays time in seconds, while the x-axis represents the steering angle in degrees, ranging from -60 to 60 degrees. At t=0 seconds, the steering angle is -50 degrees, indicating the left turn of the vehicle. Within a short period, the steering angle continuously approaches zero. At the 4-second point, the angle measures approximately -20 degrees, indicating that the car is in the process of aligning itself after making a left turn. By the time 6 seconds pass, the steering angle of the car reaches 0 degrees, which signifies that the wheels are now aligned in a straight direction. After this point, the angle continuously increases, changing into positive magnitudes. At the 12-second mark, the angle has reached around 45 degrees, indicating that the car is now executing a right turn.

The changes in time in the steering angle illustrate the vehicle's adeptness in adjusting to changes in direction. The route begins with a determined leftward turn, subsequently straightens to proceed in a straight path, and concludes with a rightward turn. The capacity to smoothly change direction is of essential importance for our project. The effective functioning of the linear motor steering control can be observed as it enables the vehicle to effectively navigate through multiple paths and execute precise turns. The graph illustrates the vehicle's ability to execute smooth left turns, maintain a straight path, and smoothly execute right turns over some time. This capability is essential for the vehicle's performance and navigation.

4.3.5 Trackless Autonomous Vehicle Path

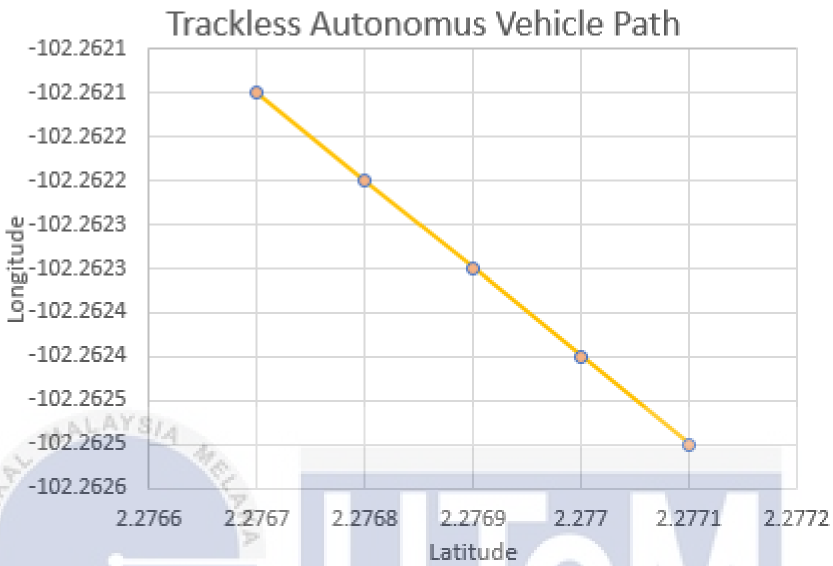


Figure 18 shows trackless autonomous vehicle path

The graph illustrates the path of an autonomous vehicle that operates without tracks, with the coordinates shown as points representing the latitude and longitude. The vehicle's path is represented as a straight line, indicating a uniform and straight movement. This suggests that the vehicle's steering control, which is generally operated by a linear motor system, is successfully maintaining the car on a precise and straight path. The latitude ranges from around 2.2766 to 2.2772, while the longitude goes from -102.2621 to -102.2626. The limited range of coordinates indicates that the vehicle is operating inside a restricted area, which is optimal for conducting tests. Every point on the line represents a recorded position, providing evidence that the vehicle follows a consistent and predictable course. This is essential for confirming the precision and dependability of the linear motor steering system.

The straight line also demonstrates the vehicle's capacity to maintain a precisely set route, illustrating the accuracy of the linear motor steering control system. Precise control at this level is essential for the design and advancement of trackless autonomous vehicles, ensuring their ability to navigate complex surroundings without the need for actual tracks. This is achieved by depending specifically on complex steering systems and motor control. The data illustrates the effective use of linear motor steering control in maintaining a constant and precise path, which is essential to the development of trackless autonomous vehicle technology.

4.3.6 Vehicle Path

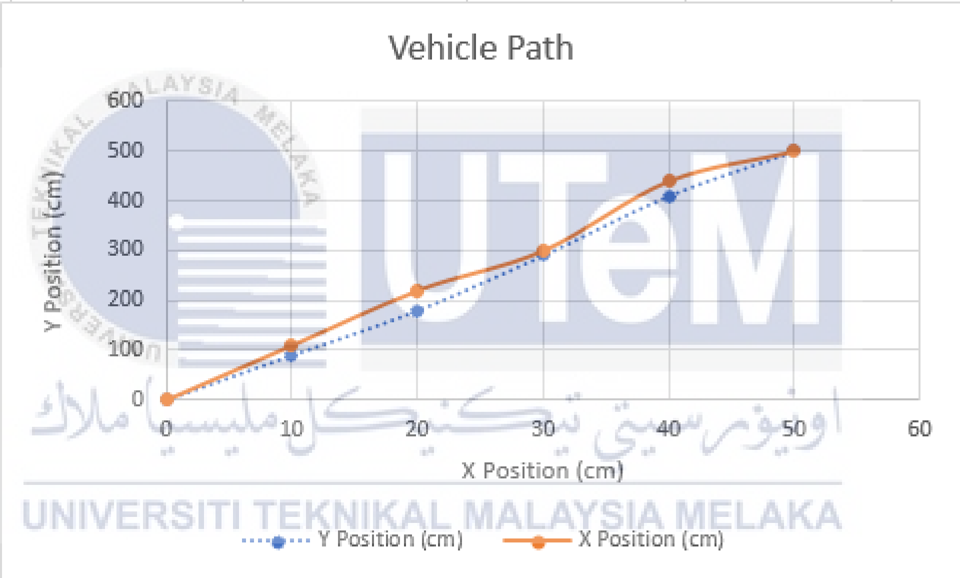


Figure 19 shows vehicle path

The graph titled "Vehicle Path" depicts the movement of a trackless autonomous vehicle, with positions recorded in centimeters along both the X and Y axes. The data points are plotted to show the vehicle's trajectory over a specified range of motion. The X Position (cm) is represented by an orange line, while the Y Position (cm) is denoted by a blue dotted line. By analyzing the graph, it is demonstrated that the vehicle's X and Y positions consistently and gradually increase as it moves forward. This suggests that the vehicle is moving along a route that includes both horizontal and vertical movement. The X Position ranges from 0 cm to 50 cm, whereas the Y Position starts at 0 cm and increases to around 500 cm.

The gradual increase in the X and Y coordinates indicates that the linear motor steering control is effectively controlling the vehicle's navigation, ensuring its smooth operation along the desired path. The minor variations in the Y Position signify the vehicle's capacity to adjust the changes or obstacles in its path, demonstrating the steering control system's response capabilities. This data is essential to evaluate the effectiveness of the linear motor steering control in a trackless autonomous vehicle. The system's precision for maintaining a path with the change, ensuring dependable navigation without the use of actual tracks. Possessing this capability is essential for the advancement of self-driving vehicles that can function in various and uncertain surroundings, depending on precise steering mechanisms to navigate with precision.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, this project can be concluded that the trackless autonomous vehicle using linear motor steering control is one of the most attractive and effective projects. From this project, we managed to reduce the dependence on human operators. This can be controlled autonomously without needed human energy. Other than that, this also can reduce operational efficiency which is the inefficient path and increased travel time. It only has to follow the path provided with the longitude and the latitude of the vehicle using GPS Sensor. Besides that, this project also limits the precision in steering and the ability to navigate through complex environments with precision. Last but not least, human errors in steering and control pose safety risks, especially in crowded or dynamic environments.

The development and progress of a trackless autonomous vehicle using linear motor steering control indicates an important development in autonomous vehicle technology. This project combines modern facilities elements, including linear actuators, BLDC motors, ultrasonic sensors, and GPS, to develop a flexible and effective autonomous system that can navigate various settings without the need for previously determined routes. By employing linear actuators and BLDC motors, the vehicle achieves accurate control and optimal performance, resulting in improved navigation and responsiveness, and enhanced reliability. GPS and adaptive control efficiently handle the irregular motion of the vehicle, enabling precise real-time decision-making and navigation. The integration of multiple sensors, including ultrasonic sensors and GPS, allows the vehicle to have an advanced knowledge of its surroundings. This enables the vehicle to locate and steer clear of obstacles ensuring the vehicle is both safe and efficient in complex environments.

To conclude overall of this project, there is no need for human efforts or energy to control the vehicle. This also can reduce the number of workers but it will benefit the country to attract the people to visit for having an excellent experience by riding this autonomous vehicle. This project proposed a trackless autonomous vehicle that will pave the way for more efficient, cost-effective, and worker-free solutions for real vehicle transportation.

5.2 Future Works

The design and development of a trackless autonomous vehicle that uses linear motor steering control offers the opportunity to many exciting new study and improvement possibilities in the future. Adding more advanced sensors, like high-resolution LIDAR and thermal cameras, to improve the vehicle's ability to detect and navigate through complicated environments is an important area for future work. Furthermore, making smarter control algorithms that use AI and machine learning could help the vehicle make more intelligent decisions and respond faster to changes in its surroundings. The vehicle could last longer and not require to be charged as often if the power management system was improved, maybe by adding renewable energy sources like solar panels.

In order implements which require real-time updates and remote control, faster technologies like 5G will be needed to improve communication systems. It would be easier to customise and improve the vehicle if its design was modular and scalable. This would make it more practical for a wider range of situations. To make sure that the vehicle can safely handle a wide range of conditions, it needs to go through a lot of safety and reliability tests in real life. The system can be made easier to use and more socially acceptable by changing how people interact with their vehicles, especially in public places.

Collaborating with government organisations to develop safety standards and guidelines would enhance trust among consumers. Participating in field trials and pilot programmes will provide useful insights and assistance in refining the technology for use in real life. At some point performing an analysis of the economic and environmental effects of these vehicles can illustrate their advantages, such as financial savings and less environmental impact in comparison to conventional vehicles. Enhancing human-machine interaction will make the vehicle easier to use and more acceptable to people. By emphasising these specific areas, future research has the potential to greatly enhance the capabilities and acceptance of trackless autonomous vehicles. In conclusion, completing an analysis of the economic and environmental effects will indicate the cost-saving potential and reduced environmental impact of these vehicles in comparison to conventional automobiles. By concentrating on these specific areas, of us may achieve significant improvements in the advancement and widespread acceptance of autonomous vehicles.

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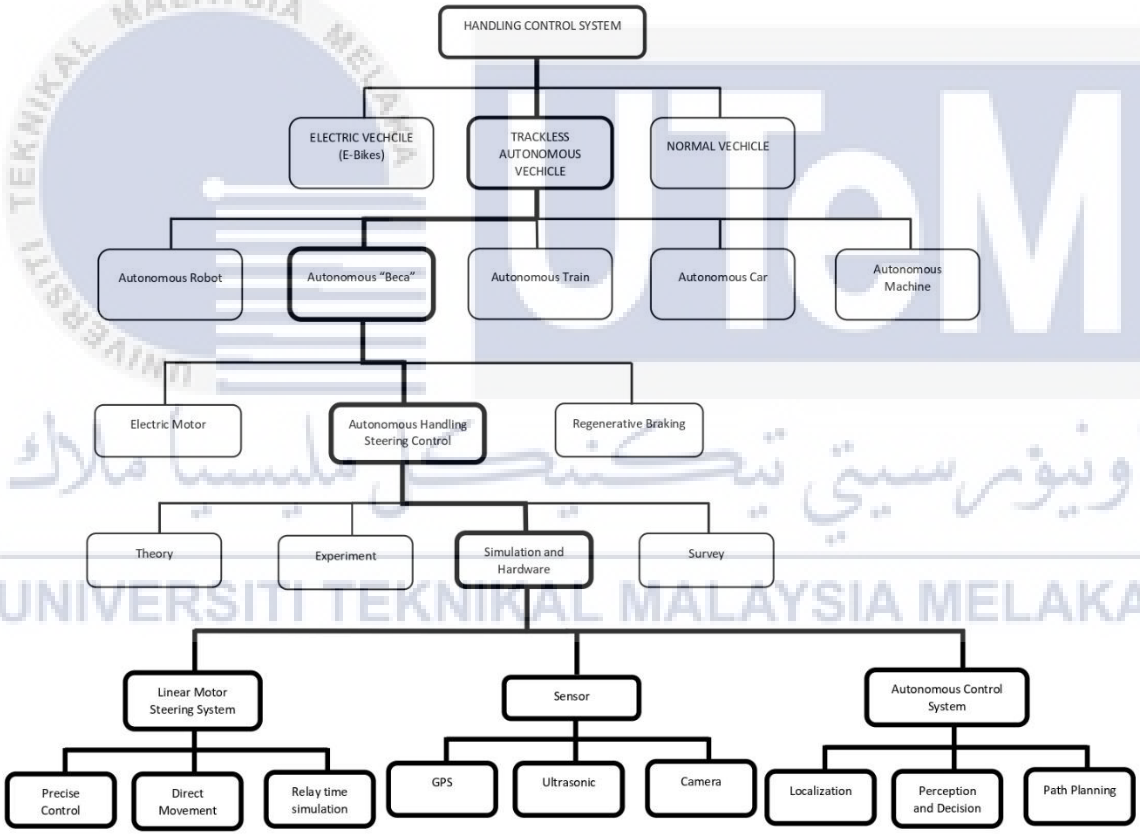
APPENDICES A - K-Chart



APPENDICES B - Coding for GPS (Global Positioning Sensor)

```
#define BLYNK_TEMPLATE_ID "TMPL6S_-Rw2W6"
#define BLYNK_TEMPLATE_NAME "E BeCA"
#define BLYNK_AUTH_TOKEN "yVVPMv3Q-8-2AMfL6_Dsjh02AOpBFSW2"

/* Comment this out to disable prints and save space */
#define BLYNK_PRINT Serial
#include <TinyGPS++.h>
#include <SoftwareSerial.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
static const int RXPin = 4, TXPin = 5;   // GPIO 4=D2(conneect Tx of GPS) and GPIO
5=D1(Connect Rx of GPS
static const uint32_t GPSBaud = 9600; //if Baud rate 9600 didn't work in your case then
use 4800

TinyGPSPlus gps; // The TinyGPS++ object
WidgetMap myMap(V9);  // V0 for virtual pin of Map Widget

SoftwareSerial ss(RXPin, TXPin);  // The serial connection to the GPS device

BlynkTimer timer;

float spd;       //Variable  to store the speed
float sats;      //Variable to store no. of satellites response
String bearing;  //Variable to store orientation or direction of GPS

//unsigned int move_index;         // moving index, to be used later
unsigned int move_index = 1;       // fixed location for now


// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "BEKIND";
char pass[] = "Nur_Adra17";
void setup()
{
  // Debug console
    Serial.begin(115200);
  Serial.println();
  ss.begin(GPSBaud);
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
  timer.setInterval(5000L, checkGPS); // every 5s check if GPS is connected, only really
needs to be done once
```

```
// You can also specify server:
  //Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass, "blynk.cloud", 80);
  //Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass, IPAddress(192,168,1,100), 8080);
}


void checkGPS(){
  if (gps.charsProcessed() < 10)
  {
    Serial.println(F("No GPS detected: check wiring."));
      Blynk.virtualWrite(V4, "GPS ERROR");  // Value Display widget  on V4 if GPS not detected
  }
}


void loop()
{
    while (ss.available() > 0)
    {
      // sketch displays information every time a new sentence is correctly encoded.
      if (gps.encode(ss.read()))
        displayInfo();
  }
  Blynk.run();
  timer.run();
}


void displayInfo()
```

```
{

if (gps.location.isValid() )
  {
    float latitude = (gps.location.lat());     //Storing the Lat. and Lon.
    float longitude = (gps.location.lng());
    float speed = gps.speed.kmph();
    Serial.print("LAT:  ");
    Serial.println(latitude, 6);  // float to x decimal places
    Serial.print("LONG: ");
    Serial.println(longitude, 6);
    Serial.print("Speed: ");
    Serial.println(speed, 6);
    Blynk.setProperty(V1, "url",
"https://maps.google.com/maps?&z=15&mrt=yp&t=k&q=" + String(latitude, 6) + "," +
String(longitude, 6));
    Blynk.virtualWrite(V2, String(latitude, 6));
    Blynk.virtualWrite(V3, String(longitude, 6));
    Blynk.virtualWrite(V9, String(longitude, 6), String(latitude, 6));
    Blynk.virtualWrite(V8, String(speed));

  }

 Serial.println();
}
```


Appendices 2

APPENDICES C - Coding for Avoid Obstacle with Ultrasonic Sensor

```
#include <ESP8266WiFi.h>

// Pin definitions
const int trigPin = 12; // D5
const int echoPin = 14; // D6

// Relay pin definitions
const int relay1Pin = 5; // D1
const int relay2Pin = 4; // D2
const int relay3Pin = 0; // D3
const int relay4Pin = 2; // D4

void setup() {
  // Initialize Serial Monitor
  Serial.begin(115200);

  // Initialize the Ultrasonic Sensor pins
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  // Initialize relay pins as OUTPUT
  pinMode(relay1Pin, OUTPUT);
  pinMode(relay2Pin, OUTPUT);
  pinMode(relay3Pin, OUTPUT);
  pinMode(relay4Pin, OUTPUT);

  // Ensure relays are off at the start
  digitalWrite(relay1Pin, LOW);
  digitalWrite(relay2Pin, LOW);
  digitalWrite(relay3Pin, LOW);
  digitalWrite(relay4Pin, LOW);
}
void loop() {
  // Variable to store the duration of pulse
  long duration;

  // Clear the trigPin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2)
```

```
// Sets the trigPin on HIGH state for 10 microseconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);

  // Calculate the distance
  long distance = duration * 0.034 / 2;

  // Print the distance on the Serial Monitor
  Serial.print("Distance: ");
  Serial.print(distance);
  Serial.println(" cm");

  // Control logic based on distance
  if (distance < 20) {
    // Reverse - Relay 2 ON, others OFF
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay2Pin, HIGH);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Reverse: Relay 2 ON");
delay(1000);  // Delay to simulate reversing
    // Turn Right - Relay 4 ON, others OFF
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, HIGH);
    Serial.println("Right: Relay 4 ON");

    delay(1000);  // Delay to simulate turning right
  } else {
    // Forward - Relay 2 and Relay 1 ON, others OFF
    digitalWrite(relay1Pin, HIGH);
    digitalWrite(relay2Pin, HIGH);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Forward: Relay 2 and Relay 1 ON");
  }

  // Wait for a while before next reading
  delay(1000);
}
```


Appendices 3

APPENDICES D - Coding for Linear Actuator Motor

```
// Define the pins connected to the motor driver
const int enablePin = 9;  // Enable pin
const int in1Pin = 8;     // Input 1
const int in2Pin = 7;     // Input 2

void setup() {
  // Set the motor control pins as outputs
  pinMode(enablePin, OUTPUT);
  pinMode(in1Pin, OUTPUT);
  pinMode(in2Pin, OUTPUT);

  // Initialize serial communication for debugging
  Serial.begin(9600);
}

void loop() {
  // Move the linear actuator in one direction
  moveLinearActuator(true); // Pass 'true' for clockwise rotation

  delay(5000); // Wait for 5 seconds

  // Move the linear actuator in the other direction
  moveLinearActuator(false); // Pass 'false' for counterclockwise rotation

  delay(5000); // Wait for 5 seconds
}

// Function to control the linear actuator
void moveLinearActuator(bool clockwise) {
  // Set the direction
  digitalWrite(in1Pin, clockwise ? HIGH : LOW);
  digitalWrite(in2Pin, clockwise ? LOW : HIGH);

  // Enable the motor
  analogWrite(enablePin, 255); // You can adjust the speed by changing the PWM value
}
```

Appendices 4

APPENDICES E - Coding for Motor

```
// Define the pins connected to the motor driver
const int enablePin = 9;  // Enable pin
const int in1Pin = 8;     // Input 1
const int in2Pin = 7;     // Input 2

void setup() {
  // Set the motor control pins as outputs
  pinMode(enablePin, OUTPUT);
  pinMode(in1Pin, OUTPUT);
  pinMode(in2Pin, OUTPUT);

  // Initialize serial communication for debugging
  Serial.begin(9600);
}

void loop() {
  // Move the motor in one direction
  moveMotor(true); // Pass 'true' for clockwise rotation

  delay(5000); // Wait for 5 seconds

  // Move the motor in the other direction
  moveMotor(false); // Pass 'false' for counterclockwise rotation

  delay(5000); // Wait for 5 seconds
}

// Function to control the motor
void moveMotor(bool clockwise) {
  // Set the direction
  digitalWrite(in1Pin, clockwise ? HIGH : LOW);
  digitalWrite(in2Pin, clockwise ? LOW : HIGH);

  // Enable the motor
  analogWrite(enablePin, 255); // You can adjust the speed by changing the PWM value
}
```

Appendices 5

APPENDICES F - Coding for Autonomous Trackless Vehicle

```
#define BLYNK_TEMPLATE_ID "TMPL6oYtkdwG-"
#define BLYNK_TEMPLATE_NAME "Motor EBeca"
#define BLYNK_AUTH_TOKEN "uTp0Q-c-_qHc92ftN-7VPuUxW2tp27hK"

/* Comment this out to disable prints and save space */
#define BLYNK_PRINT Serial
#include <TinyGPS++.h>
#include <SoftwareSerial.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "BEKIND";
char pass[] = "Nur_Adra17";

static const int RXPin = 13, TXPin = 15;   // GPIO 4=D2(conneect Tx of GPS) and
GPIO 5=D1(Connect Rx of GPS
static const uint32_t GPSBaud = 9600; //if Baud rate 9600 didn't work in your case then
use 4800

TinyGPSPlus gps; // The TinyGPS++ object
WidgetMap myMap(V9);  // V0 for virtual pin of Map Widget

SoftwareSerial ss(RXPin, TXPin);  // The serial connection to the GPS device

BlynkTimer timer;

float spd;       //Variable  to store the speed
float sats;      //Variable to store no. of satellites response
String bearing;  //Variable to store orientation or direction of GPS

//unsigned int move_index;         // moving index, to be used later
unsigned int move_index = 1;       // fixed location for now

const int trigPin = 12;
const int echoPin = 14;

const int relay1Pin = 5; // D1
const int relay2Pin = 4; // D2
const int relay3Pin = 0; // D3
const int relay4Pin = 2; // D4
```

```
#define SOUND_VELOCITY 0.034 // ultrasonic variable
#define CM_TO_INCH 0.393701

long duration;
float distanceCm;
float distanceInch;

bool ultrasonicActive = false; // Flag to control ultrasonic sensor activity

BLYNK_WRITE(V0) { // reverse
  int k = param.asInt();
  if (k == 1) {
    digitalWrite(relay2Pin, HIGH);
    delay(500);
    digitalWrite(relay1Pin, HIGH);
  } else if (k == 0) {
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay1Pin, LOW);
  }
}

BLYNK_WRITE(V1) { // forward
  int l = param.asInt();
  if (l == 1) {
    digitalWrite(relay1Pin, HIGH);
  } else if (l == 0) {
    digitalWrite(relay1Pin, LOW);
  }
}
BLYNK_WRITE(V2) { // right
  int m = param.asInt();
  if (m == 1) {
    digitalWrite(relay3Pin, HIGH);
  } else if (m == 0) {
    digitalWrite(relay3Pin, LOW);
  }
}

BLYNK_WRITE(V3) { // left
  int n = param.asInt();
  if (n == 1) {
    digitalWrite(relay4Pin, HIGH);
  } else if (n == 0) {
    digitalWrite(relay4Pin, LOW);
  }
}
```

```
BLYNK_WRITE(V4) { // ultrasonic
  int p = param.asInt();
  ultrasonicActive = (p == 1); // Set flag based on button state
  if (!ultrasonicActive) {
    // Stop all relays if ultrasonic is deactivated
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
  }
}

void checkUltrasonic() {
  // Clears the trigPin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin on HIGH state for 10 micro seconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);

  // Calculate the distance
  distanceCm = duration * SOUND_VELOCITY / 2;

  // Convert to inches
  distanceInch = distanceCm * CM_TO_INCH;
  // Prints the distance on the Serial Monitor
  Serial.print("Distance (cm): ");
  Serial.println(distanceCm);
  Serial.print("Distance (inch): ");
  Serial.println(distanceInch);

  if (distanceCm < 30) {
    Serial.println("Obstacle detected < 30cm ");

    // Stop - All relay OFF
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Stop");
    delay(2000);

    // Reverse - Relay 1 and Relay 2 ON, Other OFF
    digitalWrite(relay2Pin, HIGH);
    delay(500);
    digitalWrite(relay1Pin, HIGH);
```

```
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Reverse: Relay 1 and Relay 2 ON");
    delay(1000);

    // Turn Right - Relay 3 ON, Other OFF
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay3Pin, HIGH);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Turn Right");
    delay(4000);

    // Forward - Relay 1 ON, Other OFF
    digitalWrite(relay1Pin, HIGH);
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Forward: Relay 1 ON");
    delay(2000);
// Turn Left - Relay 4 ON, Other OFF
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, HIGH);
    Serial.println("Turn Left");
    delay(4000);

    // STOP - All Relay OFF
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Stop-");
  } else {
    // Forward - Relay 1 ON, others OFF
    digitalWrite(relay1Pin, HIGH);
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Forward: Relay 1 ON");
  }
}
void setup() {
  // Debug console
  Serial.begin(115200);
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input

  pinMode(relay1Pin, OUTPUT);
```

```
  pinMode(relay2Pin, OUTPUT);
  pinMode(relay3Pin, OUTPUT);
  pinMode(relay4Pin, OUTPUT);

  Serial.println();
  ss.begin(GPSBaud);
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
   timer.setInterval(5000L, checkGPS); // every 5s check if GPS is connected, only really needs to be done once
}

void checkGPS(){
  if (gps.charsProcessed() < 10)
  {
    Serial.println(F("No GPS detected: check wiring."));
      Blynk.virtualWrite(V10, "GPS ERROR");  // Value Display widget  on V10 if GPS not detected
  }
}

void loop() {
  while (ss.available() > 0)
    {
      // sketch displays information every time a new sentence is correctly encoded.
      if (gps.encode(ss.read()))
        displayInfo();
}
  Blynk.run();
   timer.run();

  // Check ultrasonic sensor if it's active
  if (ultrasonicActive) {
    checkUltrasonic();
    delay(100); // Small delay to avoid overwhelming the sensor
  }
}

void displayInfo()
{
  if (gps.location.isValid() )
  {
    float latitude = (gps.location.lat());     //Storing the Lat. and Lon.
    float longitude = (gps.location.lng());
    float speed = gps.speed.kmph();
    Serial.print("LAT:  ");
    Serial.println(latitude, 6);  // float to x decimal places
    Serial.print("LONG: ");
    Serial.println(longitude, 6);
    Serial.print("Speed: ");
    Serial.println(speed, 6);
```

```
    Blynk.setProperty(V7, "url",
"https://maps.google.com/maps?&z=15&mrt=yp&t=k&q=" + String(latitude, 6) + "," +
String(longitude, 6));
    Blynk.virtualWrite(V5, String(latitude, 6));
    Blynk.virtualWrite(V6, String(longitude, 6));
    Blynk.virtualWrite(V9, String(longitude, 6), String(latitude, 6));
    Blynk.virtualWrite(V8, String(speed));

  }

 Serial.println();
}
```


Appendices 6

APPENDICES G - Coding for Combination of Motor

```
#define BLYNK_TEMPLATE_ID "TMPL6oYtkdwG-"
#define BLYNK_TEMPLATE_NAME "Motor EBeca"
#define BLYNK_AUTH_TOKEN "uTp0Q-c-_qHc92ftN-7VPuUxW2tp27hK"

/* Comment this out to disable prints and save space */
#define BLYNK_PRINT Serial


#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "BEKIND";
char pass[] = "Nur_Adra17";

const int trigPin = 12;
const int echoPin = 14;

const int relay1Pin = 5; // D1
const int relay2Pin = 4; // D2
const int relay3Pin = 0; // D3
const int relay4Pin = 2; // D4

#define SOUND_VELOCITY 0.034 // ultrasonic variable
#define CM_TO_INCH 0.393701

long duration;
float distanceCm;
float distanceInch;

BLYNK_WRITE(V0) { // reverse
int k = param.asInt();
if (k ==1) {
digitalWrite(relay2Pin, HIGH);
delay(500);
digitalWrite(relay1Pin, HIGH);
} else if(k==0) {
digitalWrite(relay2Pin, LOW);
digitalWrite(relay1Pin, LOW);
}
}

BLYNK_WRITE(V1) { // foward
int l = param.asInt();
if (l ==1) {
```

```
digitalWrite(relay1Pin, HIGH);
#define BLYNK_TEMPLATE_ID "TMPL6oYtkdwG-"
#define BLYNK_TEMPLATE_NAME "Motor EBeca"
#define BLYNK_AUTH_TOKEN "uTp0Q-c-_qHc92ftN-7VPuUxW2tp27hK"

/* Comment this out to disable prints and save space */
#define BLYNK_PRINT Serial


#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "BEKIND";
char pass[] = "Nur_Adra17";

const int trigPin = 12;
const int echoPin = 14;

const int relay1Pin = 5; // D1
const int relay2Pin = 4; // D2
const int relay3Pin = 0; // D3
const int relay4Pin = 2; // D4

#define SOUND_VELOCITY 0.034 // ultrasonic variable
#define CM_TO_INCH 0.393701

long duration;
float distanceCm;
float distanceInch;

BLYNK_WRITE(V0) { // reverse
int k = param.asInt();
if (k ==1) {
digitalWrite(relay2Pin, HIGH);
delay(500);
digitalWrite(relay1Pin, HIGH);
} else if(k==0) {
digitalWrite(relay2Pin, LOW);
digitalWrite(relay1Pin, LOW);
}
}

BLYNK_WRITE(V1) { // foward
int l = param.asInt();
if (l ==1) {
digitalWrite(relay1Pin, HIGH);

// Reads the echoPin, returns the sound wave travel time in microseconds
```

```
 duration = pulseIn(echoPin, HIGH);

 // Calculate the distance
 distanceCm = duration * SOUND_VELOCITY/2;

 // Convert to inches
 distanceInch = distanceCm * CM_TO_INCH;

 // Prints the distance on the Serial Monitor
 Serial.print("Distance (cm): ");
 Serial.println(distanceCm);
 Serial.print("Distance (inch): ");
 Serial.println(distanceInch);

if (distanceCm < 30) {
   Serial.println("Obstacle detected < 30cm ");

   // Stop - All relay OFF

   digitalWrite(relay2Pin, LOW);
   digitalWrite(relay1Pin, LOW);
   digitalWrite(relay3Pin, LOW);
   digitalWrite(relay4Pin, LOW);
   Serial.println("Stop");
   delay(2000);

   // Reverse - Relay 1 and Relay 2 ON, Other OFF
   digitalWrite(relay2Pin, HIGH);
   delay(500);
   digitalWrite(relay1Pin, HIGH);
   digitalWrite(relay3Pin, LOW);
   digitalWrite(relay4Pin, LOW);
   Serial.println("Reverse: Relay 1 and Relay 2 ON");
   delay(1000);

   // Turn Right - Relay 3 ON, Other OFF
   digitalWrite(relay2Pin, LOW);
   digitalWrite(relay1Pin, LOW);
   digitalWrite(relay3Pin, HIGH);
   digitalWrite(relay4Pin, LOW);
   Serial.println("Turn Rigt");
   delay(4000);

   // Foward - Relay 1 ON, Other OFF
   digitalWrite(relay1Pin, HIGH);
   digitalWrite(relay2Pin, LOW);
   digitalWrite(relay3Pin, LOW);
   digitalWrite(relay4Pin, LOW);
   Serial.println("Forward: Relay 1 ON");
   delay(2000);
```

```
// Turn Left - Relay 4 ON, Other OFF
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, HIGH);
    Serial.println("Turn Left");
    delay(4000);

    // STOP - All Relay OFF
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay1Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Stop-");

} else {
    // Forward - Relay 1 ON, others OFF
    digitalWrite(relay1Pin, HIGH);
    digitalWrite(relay2Pin, LOW);
    digitalWrite(relay3Pin, LOW);
    digitalWrite(relay4Pin, LOW);
    Serial.println("Forward: Relay 1 ON");
  }

  // Wait for a while before next reading


} else if(p==0) {

digitalWrite(relay1Pin, LOW);
digitalWrite(relay2Pin, LOW);
digitalWrite(relay3Pin, LOW);
digitalWrite(relay4Pin, LOW);

}
}
void setup()
{
  // Debug console
  Serial.begin(115200);
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input

 pinMode(relay1Pin,OUTPUT);
 pinMode(relay2Pin,OUTPUT);
 pinMode(relay3Pin,OUTPUT);
 pinMode(relay4Pin,OUTPUT);

 //delay(500);
  //digitalWrite(relay1Pin, HIGH);
```

```
  //digitalWrite(relay2Pin, LOW);
  //digitalWrite(relay3Pin, LOW);
  //digitalWrite(relay4Pin, LOW);
  //Serial.println("Initial State: Moving Forward");

  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
  // You can also specify server:
  //Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass, "blynk.cloud", 80);
  //Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass, IPAddress(192,168,1,100), 8080);
}
void loop()
{
  Blynk.run();
  // You can inject your own code or combine it with other sketches.
  // Check other examples on how to communicate with Blynk. Remember
  // to avoid delay() function!
}
```


Appendices 7