International Journal of Computational Science and Engineering Research
ISSN: 3107 -8605 (Online) , http://www.ijcser.com/
Regular Issue , Vol.1, Issue. 3 (July – September) , 2024 , Pages: 45 - 56
Received : 30 April 2024 ; *Accepted :* 10 June 2024 ; *Published :* 15 September 2024
https://doi.org/10.63328/IJCSER-V1RI3P11
Original : Applied Research – Experimental Research Paper

Smart Electric Bicycle

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Abstract: The transition to electric vehicles (EVs) has gained significant momentum globally due to concerns over environmental sustainability and energy security. This project aims to design and develop an electric vehicle system that addresses the challenges such as range anxiety, charging infrastructure, and cost. The project will involve the integration of battery technologies, electric motors, power electronics, and control systems to optimize efficiency and enhance driving experience. Through this project, we aim to contribute to the advancement of electric vehicle technology and accelerate the adoption of sustainable transportation solutions. The project employs a multidisciplinary approach, combining principles from mechanical engineering, electrical engineering, and human factors design. Key components of the project include the selection and integration of high-performance lithium-ion battery packs, the development of efficient motor control algorithms, and the implementation of user-friendly interface systems for seamless interaction between the rider and the e-bike. This project focuses on the implementation of voice control features for an electric bicycle, enhancing user convenience and accessibility. The system integrates voice commands for starting and stopping the bicycle, as well as monitoring the battery level through a start of charge mechanism. Key components utilized include a BLDC motor, controller, and Battery Management System (BMS). The voice control functionality offers a hands-free operation experience, ensuring safety and ease of use for riders. By leveraging modern technology, this project aims to demonstrate the feasibility and practicality of integrating voice commands into electric bicycles, thereby enhancing their functionality and user experience.

Keywords: BLDC Motor, Lithium-ion Battery, Voice Command, DC Controller, Battery Management System.

1. Introduction

1.1. Evolution of Electric Bicycle

The concept of an electric bicycle can be tracked back to the early 19th century, with various inventors experimenting with electric propulsion for bicycles. In the 1890s, electric bicycles were documented within various U.S. patents. On 31 December 1895, Ogden Bolton Jr. was granted a patent for a battery powered bicycle with 6-pole brush-and-commutator direct current (DC) hub motors mounted in the rear wheel. Seven years later, in 1897, Hosea W. Libbey of Boston invented an electric bicycle that was propelled by a "double electric motor". The motor was designed within the hub of the crank set axle. From 1992, Vector Services Limited offered the Zike Electric Bicycle. The bicycle included NiCd batteries that were built into a frame member and included an 850 g permanent magnet motor. American car executive Lee Iacocca founded EV Global Motors in 1997, a company that produced an electric bicycle model named E-bike SX, and it was one of the early efforts to popularize e-bikes in the US. The early 20th century saw limited advancements in electric bicycle technology due to the limitations of batteries and electric motors. The 20th century marked a turning point for electric bikes, with significant technological advancements and increasing interest from consumers.

1.2. Background

The concept of electric bicycles (e-bikes) has been around for decades, but recent advancements in technology have propelled their popularity to new heights. E-bikes combine the traditional benefits of cycling with electric propulsion systems, offering a greener, more efficient mode of transportation. With the global emphasis on reducing carbon emissions and promoting sustainable living, e-bikes have emerged as a practical solution for urban mobility and recreational activities.***Benefits of Electric Bicycle:***

Environmental Impacts: E-bikes produce zero emissions, making them an eco-friendly alternative to cars and motorcycles. By choosing e-bikes over fossil fuel-powered vehicles, individuals can significantly reduce their carbon footprint.

ISSN: 3107 - 8605 (Online) , http://www.ijcser.com/ , Vol. 1 , Issue. 3 , 2024 , https://doi.org/10.63328/IJCSER-V1RI3P11

Health and Fitness : While e-bikes provide electric assistance, they still require pedalling, offering health benefits similar to traditional cycling. This makes e-bikes a great option for individuals looking to improve their fitness levels without overexerting themselves.

Cost Savings: Over time, e-bikes can offer substantial cost savings compared to cars or public transportation, especially for daily commuting. They require less maintenance, no fuel costs, and often come with extended warranties on batteries and electric components.

Market Trends and Growth: The global e-bike market has witnessed exponential growth in recent years, driven by technological advancements, urbanization, and changing consumer preferences. According to market research reports, the e-bike market is expected to continue growing at a CAGR (Compound Annual Growth Rate) of over 6% in the next few years. This growth can be attributed to factors such as government incentives, improved infrastructure, and increased awareness about the benefits of e-bikes.

1.3. Problem Statement

Challenges and limitations : Despite the numerous benefits and growing popularity, e-bikes face several challenges that need to be addressed.

Range Anxiety: One of the primary concerns for potential e-bike users is range anxiety. The fear of running out of battery power mid-journey can deter many from adopting e-bikes for daily commuting or long-distance travel.

Cost Barrier : The initial cost of purchasing an e-bike is often higher than that of a traditional bicycle or scooter, making it less accessible to a broader audience, especially in developing countries.

Weight and Handling: The added weight of batteries and electric components can affect the overall handling the e-bike, particularly at higher speeds or on challenging terrains.

Safety Concerns: With the increasing number of e-bikes on the roads, there is a growing need for regulations, awareness campaigns, and safety features to ensure the well-being of riders and pedestrians alike.

1.4. Objectives

Project goals and objectives: The primary objectives of this project are:

Design Optimization: To develop an e-bike design that prioritizes efficiency, lightweight construction, and cost-effectiveness without compromising on performance and safety.

Range Improvement: To enhance the battery range and energy efficiency of the e-bike through innovative design strategies, component selection, and optimization techniques.

Safety Enhancement: To integrate advanced safety features, promote safe riding practices, and raise awareness about e-bike safety among users and stakeholders.

Cost Reduction: To explore and implement cost-effective solutions for manufacturing, assembly, and maintenance without compromising on the quality and reliability of the e-bike.

1.5. Scope of the Project

Project Scope and deliverables: The scope of this project encompasses the following key areas:

Design and Development: From conceptualization to prototyping, the project will focus on designing an innovative and efficient e-bike that meets the project objectives and user requirements.

Component Selection and Integration: A comprehensive evaluation and selection process will be undertaken to choose the most suitable components, including motors, batteries, controllers, and sensors, for optimal performance and efficiency.

Simulation and Analysis: Advanced simulation tools and techniques will be employed to analyse and optimize key parameters such as range, efficiency, and safety under various operating conditions.

Testing and Validation: Rigorous real-world testing and validation procedures will be conducted to assess the design, performance, safety, and reliability of the e-bike prototype.

Documentation and Reporting: All findings, methodologies, results, and recommendations will be meticulously documented and presented in the form of a comprehensive thesis report to fulfil the academic requirements of the B. Tech program.

1.6. Significance of the Study

Contribution to the field: This project aims to make a significant contribution to the field of electric bicycles by:

Innovative Design: Introducing a new design approach that combines lightweight materials,

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advanced battery technology, and user-friendly features to enhance the overall e-bike experience.

Safety Enhancement: Developing and implementing innovative safety features and systems to reduce the risk of accidents and injuries associated with e-bike use.

Market Insights: Providing valuable insights into consumer preferences, market trends, and opportunities for innovation in the e-bike industry through comprehensive market analysis and research.

2. Related Work

Electric Bicycle (E-bike) Trends, Impacts, and Opportunities Electric bicycles (e-bikes) are a rapidly growing transportation mode with significant potential to impact various aspects of our lives. This literature survey examines relevant research to understand the current landscape of e-bikes, their evolving role in transportation, and their potential benefits and challenges.

E-bike Growth and Motivations: Several studies highlight the surging popularity of e-bikes, attributed to factors like reduced reliance on cars, improved health benefits for riders, and increased accessibility for diverse demographics [1, 3].

Environmental Impact : Research suggests that e-bikes can be a powerful tool for environmental sustainability. Studies by Philips et al. (2020) demonstrate e-bikes' potential to significantly reduce CO2 emissions compared to traditional gasoline-powered vehicles [3].

Technological Advancements

Lithium-ion batteries are the dominant battery technology for e-bikes due to their superior energy density, minimal self-discharge, and long lifespans [5, 6, 8]. Battery management systems (BMS) are crucial for e-bike safety, performance, and longevity. Research by Rashid et al. (2017) explores the role of BMS in monitoring battery health and optimizing charging/discharging cycles [8]. Accurately determining a battery's state-of-charge (SOC) and state-of-health (SOH) is essential for optimal e-bike performance. Several studies investigate various methods for SOC/SOH estimation, including those by Taborelli et al. (2017) and Xu et al. (2013) [10, 12].

Emerging Trends in E-bikes: The potential integration of voice assistants with e-bikes for controlling functionalities is explored in research by Ammari et al. (2019) [14].

Smart e-bikes equipped with features like weight-minimized power packs, rider data-driven fatigue detection, GPS tracking, and real-time data monitoring systems are presented in studies by Silva et al. (2021) and Kiefer et al. (2015) [16, 17].

Future Considerations: While lithium-ion batteries are currently dominant, research by Hadjipaschalis et al. (2008) highlights the ongoing exploration of alternative energy storage technologies for electric vehicles [18].

Challenges and Further Research: E-bikes also present challenges related to safety regulations, infrastructure development, equitable access, and environmental considerations. Further research is needed to address these concerns and ensure the sustainable and inclusive integration of e-bikes into our transportation systems.

3. Theory and Calculation

3.1. Distance Travelled:

To calculate the distance that can be travelled by the electric bicycle, we need to know the energy capacity of the battery and the power consumption of the motor.
Battery capacity = 24 V, 14 Ah
Power rating of the motor = 350 W

Firstly, we calculate the energy capacity of the battery:
Energy capacity = Voltage*Ampere hours
Energy capacity = 24 V*14 Ah
Energy capacity = 336 Wh

Next, we calculate the power consumption of the motor:
Since the motor's rated power is 350 W, and the motor is running at full load, we can assume it consumes power close to its rated power.
Power consumption = 350 W

Now we find out how much time the battery can power the motor:
Time = Energy capacity/Power consumption
Time = 336 Wh /350 W
Time = 0.96 hours
Since the battery is fully charged in 3 hours, we can assume that it can provide power for approximately 0.96 hours.

Now, we calculate the distance travelled during this time:
Speed of the bicycle assumed = 30 km/h
Distance travelled = Speed*time
Distance travelled = 30 km/h*0.96 hours
Distance travelled = 30 km
So, the electric bicycle can travel approximately 30 km when the battery is fully charged, moving at a speed of 30 km/h with a load of 60 kg.

ISSN: 3107 - 8605 (Online) , http://www.ijcser.com/ , Vol. 1 , Issue. 3 , 2024 , https://doi.org/10.63328/IJCSER-V1RI3P11

3.2 Distance travelled under no load:

Power consumption of the motor = 350 W (under full load)
No load situation implies the motor is still running but not actively propelling any load
Let's assume the motor consumes a constant amount of power even when there is no load. This is often referred to as the idle or no-load power consumption.
Without specific information on the idle power consumption of the motor, we can't provide an exact calculation. However, we can make an estimate based on typical values for idle power consumption of similar motors.
If we assume an idle power consumption of, for example, 10% of the rated power (which is a common approximation for many motors), then:
Idle power consumption = 10% of 350 W = 35 W

Now, let's assume the battery has a similar energy capacity as before, which is 336 Wh. To calculate the hypothetical distance travelled under no load, we can use the same formula as before.

Distance travelled = Speed * Time
Speed of the bicycle = 30 km/h (just for consistency
However, instead of considering the total time until the battery is depleted, we'll consider the time until the energy consumed equals the energy capacity of the battery, assuming the motor is running continuously at its idle power consumption

Time = Energy capacity/Power consumption
Time = 336 Wh/35 W
Time = 9.6 hours

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4. Experimental Method

4.1. Implementing Lithium-ion battery for electric bicycle

A lithium-ion or Li-ion battery is a type of rechargeable battery that uses the reversible intercalation of Li+ ions into electronically conducting solids to store energy. In comparison with other commercial rechargeable batteries, Li-ion batteries are characterized by higher specific energy, higher energy density, higher energy efficiency, a longer cycle life, and a longer calendar life.

The cost of lithium-ion batteries is quite expensive compared to other battery, instead of buying the lithium-ion battery, if the battery is prepared by using lithium-ion cells, then the cost is reduced. The desired voltage and current of lithium-ion battery is 24V,14Ah. The lithium-ion cells with rating of 3.7V and 2Ah are taken to prepare the lithium-ion battery pack. Connecting batteries in series and parallel is a common technique used to achieve specific voltage and capacity requirements in battery systems. The important specifications of a lithium-ion battery are

Voltage (V): Voltage measures the force of the flow of electricity from the battery to the motor. The higher the voltage of an e-bike battery, the more power it can provide to the motor, typically allowing an e-bike to reach higher max speeds. . When we connect batteries in series, we are essentially connecting the positive terminal of one battery to the negative terminal of another. This increases the total voltage of the battery pack while keeping the capacity the same. The voltage of each battery adds up, while the capacity remains the same.

3.7V * 7 = 24V

Amps (A): Amps,' named after French mathematician André-Marie Ampère, are the unit of measurement of the flow of electric current through a circuit. Amps measure the amount of energy being drawn from the bike's battery at a given moment. The more Amps being drawn, the more power the motor can produce. E-bike manufacturers typically provide an Amp-hour rating instead of an Amp rating alone.

Amp-Hours (Ah): Amp-hours measure how many Amps the battery can deliver over an hour period. For example, a 14 Ah battery can provide 14 A for one hour or 7 A for two hours. While this is useful information for determining range, it is best taken in the context of the motor's voltage. Doing so gives a measurement of the total energy capacity of a battery (Watt-hours). When we connect batteries in parallel, we are connecting the positive terminals together and the negative terminals together. This increases the total capacity of the battery pack while keeping the voltage the same. The capacity of each battery adds up, while the voltage remains the same.

2Ah * 7 = 14Ah

Watt-Hours (Wh): Watt-hours is a measure of the battery's total energy capacity. This number is calculated by multiplying voltage and Amp-hours (V×Ah=Wh). This measurement is more informative than the Ah rating alone, as it accounts for the force and volume of the flow of electrical current. However, it is just a small part of determining electric bike range. A motor's efficiency, total payload weight, weather conditions, elevation gain, and many other factors determine the range, which we will cover in an upcoming section. When connecting batteries in parallel, we should make sure that they have similar capacities and states of health to avoid issues like one battery discharging into another. Proper balancing and monitoring are crucial in large battery packs to ensure uniform charging and discharging across all cells. Therefore, the capacity of the battery

24v * 14Ah = 340 W

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Watts (W): Watts is a measurement of the power being produced by the motor. Manufacturers typically provide two 'W' ratings; continuous (nominal) and peak. The continuous power output is the max output a motor can sustain for a given period of time. The peak power is the max it can achieve in an instant or for a short burst.

4.2. Battery Management System of lithium-ion battery

Lithium-ion or LiFePO4 batteries are more susceptible to damage from certain conditions, such as overcharging, undercharging, and overheating. To harness the full potential of these batteries, The BMS communicates with the onboard charger to monitor and control the charging of the battery pack. It also helps maximize the range of the vehicle by optimally using the amount of energy stored in it. By monitoring key parameters such as state of charge (SOC), state of health (SOH), and temperature, a BMS can prevent overcharging, over-discharging, and thermal stress — all of which can significantly reduce the life expectancy of batteries. selecting the right BMS for battery system is crucial for ensuring the safety and longevity of battery A BMS may protect its battery by preventing it from operating outside its safe operating area, such as:

Over-charging

Over-discharging

Over-current during charging

Over-current during discharging

Over-voltage during charging, especially important for lead–acid, Li-ion and LiFePO4 cells

Under-voltage during discharging, especially important for Li-ion and LiFePO4 cells

Over-temperature

Under-temperature

Over-pressure (NiMH batteries)

Ground fault or leakage current detection

Since we are using 7 cells in series and 7 in parallel, we are selecting 7S BMS with discharge and charge current of 10A.In the 7S BMS there will be 7 balance wires that should be connected to 7 group of cells which are in series and 2 main wires which are positive(B+) and negative(B). Each balance wire corresponds to one series group of cells, we Connected the first balance wire to the positive terminal of the first series group which is the positive terminal of the entire battery pack, and connected the second balance wire to the connection point between the first and second series groups, and by continuing this pattern we have connected each subsequent balance wire to the connection point between each series group. The last i.e. seventh balance wire is connected to the negative terminal of the last series group. This configuration allows the BMS to effectively manage the battery pack's performance and protect against overcharging or over discharging of individual cells.

4.3. DC Controller:

DC controller is a component that connects all electrical parts on the electric bicycle together. It connects things like the battery, motor, throttle, brake light, brake wire. It is a small computer that acts as the heart of the electric bicycle.

4.3.1. Controller circuit design:

Main control chip: Electric bicycle features high-performance PIC16F72 microcontroller core. PIC16F72 has 28 pins, include 22 8-bit I/O ports. The PIC16F72 supports PWM for motor control. CCP1 pin can output the maximum resolution of 10BIT adjustable PWM signal. AR0~AR4 pins support A/D conversion, they are used to detect changing of voltage and current when electric bicycle is running. Speed controlled signal, helping signal, current detection signal was transmitted to RA1, RA4, RA5 respectively. Hall signals from hall sensor were transmitted to RC5, RC6. Signals of motor driving were transmitted to RB2 to RB7.

Power Supply : The power of this controller was divided into two parts 5V supply voltage to MCU and 12V supply voltage to drive MOSFET. External power source adopts 24V DC voltage. LM2576 series of regulators are monolithic integrated circuits, all circuits of this series are capable of driving a 3.0A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, 12V, 15V and adjustable output version. To get 5V DC voltage, LM2576-5 was used. In the same way, to get 12V DC voltage, LM2576-12 was used.

Input of hall signal: Most motor used in electric bicycle today is brushless DC motor, there is no friction between electric brush and commutator inside the motor, there are no need to replace electric brush and some other vulnerable components. So, it prolongs life of the motor. There are three hall sensors inside the brushless DC motor. They transmit signal of rotor position to PIC16F72.

Current Detection: There are some heavy-current situations when electric bicycle is running. Such as motor is starting and loading too much. Coil Winding and electric components will be damaged by heavy-current in controller. Through measure Voltage crossed Current-measure resistance, when voltage was measured exceed voltage which defined previous. It indicates current exceed safe range, power MOSFET will be closed in short time. Reference potential was transmitted to non-inverting input pin, the voltage cross R9 was transmitted to inverting input pin in LM358. When voltage was measured exceed reference potential, the

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output level will be changed and the data transmitted to MCU, MCU stop the motor.

Brake Circuit: The electric bicycle should be brake, when some unexpected things happened. When driver brake, the power supply should be stopped. High-level is a brake signal in this controller. Hall sensor output low level in normal condition, low-level will be changed to high-level when braking.

The level to base of transistor is conversed when braking, and output level will be conversed. This conversed level is transmitted to MCU finally. MCU closes the power supplied.

Helping Function: Electric bicycle is also named moped, when people tread of foot pedal, the motor will run in small power, dynamic torque signal can be detected by torque sensor inside electric bicycle, when people tread of foot pedal. When dynamic torque signal transmitted to MCU, the motor will be driven in a short time. The function of helping does not only save electricity energy, prolong the life of battery, but also improve physical condition. The voyage of electric bicycle doubled than traditional electric bicycle. Because of smaller current, components damaged by strong current will be avoided.

Checking of Voltage Supply: In order to avoid the low voltage supply, which affect the electric bicycle running normally. Controller should be provided with Capacity checking. The voltage crossed sampling resistance transmitted to MCU, signals the voltage supply to controller, when voltage is smaller than defined previous. it will reminder people to charge up the electric bicycle battery.

Design of controller software: Software is fairly integral part of controller. Software system design includes the following several modules:

A/D sampling and conversion

PWM module

Over-current protection, under-voltage protection and helping module

System initialled automatically when MCU powered on. Many components were initialled include: PWM, A/D conversion, I/O ports and timer setting.

4.3.2. Controller specifications:

Voltage	:	DC 24V
Under pressure	:	20V +- 1
Current limit	:	32A +- 1
Level brake	:	low level
Turn voltage	:	1.1-4.3V
Phase angle	:	60/120

4.3.3. Functionality of a Controller

A controller is also called as brain of an e-bike. The primary function of a controller is to regulate power flow from battery to the other parts i.e. motor, brake light, throttle and brakes. It ensures that the other parts receive the appropriate voltage and current to operate efficiently. DC controller enables smooth acceleration and deacceleration of the electric bicycle. By modulating the power output in response to rider input or external factors such as terrain and traffic conditions, controllers ensure a comfortable and safe riding experience. Controllers are rated based on their voltage and current handling capabilities, which should match the specifications of the battery and motor they are paired with. The features of controller are overcurrent protection and overvoltage protection which prevents damage to the controller and motor during high current conditions and safe guards the system from voltage spikes that could damage components. The DC Controller consist of 8 attachments that includes for motor, acceleration, brake, battery, charging, brake light, power lock.

4.3.4. Advantages of Controller

Controlled Power Delivery: The controller regulates the power flow from the battery to the motor, ensuring smooth and controlled acceleration and deceleration. This helps in maintaining stability and control over the bike's speed and performance.

Compatibility: A 24V DC controller is often compatible with various types of motors and batteries commonly used in electric bicycles, providing flexibility in design and integration.

Efficiency : By precisely managing the power delivery, the controller helps in optimizing the energy efficiency of the electric bicycle, thereby extending the range per charge and improving overall battery life.

Safety : The controller incorporates safety features such as overcurrent protection, overvoltage protection, and thermal management to prevent damage to the motor, battery, and other components, ensuring safe operation of the electric bicycle.

Smooth Riding Experience : With a well-tuned controller, riders can experience a smoother and more responsive riding experience, with seamless transitions between pedalling and electric-assist modes.

4.4. Brushless DC Electric Motor

A brushless DC electric motor (BLDC), also known as an electronically commutated motor, is a synchronous motor using a direct current (DC) electric power supply. a BLDC doesn't use brushes for commutation but rather they are electronically commutated. In

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conventional Brushed DC Motors, the brushes are used to transmit the power to the rotor as they turn in a fixed magnetic field. As mentioned earlier, a BLDC motor used electronic commutation and thus eliminates the mechanically torn brushes.

Since there are no brushes in a BLDC Motor, the commutation is controlled electronically. In order to rotate the motor, the windings of the stator must be energized in a sequence and the position of the rotor (i.e. the North and South poles of the rotor) must be known to precisely energize a particular set of stator windings.

A Position Sensor, which is usually a Hall Sensor (that works on the principle of Hall Effect) is generally used to detect the position of the rotor and transform it into an electrical signal. Most

BLDC Motors use three Hall Sensors that are embedded into the stator to sense the rotor's position. The output of the Hall Sensor will be either HIGH or LOW depending on whether the North or South pole of the rotor passes near it. By combining the results from the three sensors, the exact sequence of energizing can be determined.

The construction of a brushless motor system is typically similar to a permanent magnet synchronous motor (PMSM), but can also be a switched reluctance motor, or an induction (asynchronous) motor.

The advantages of a brushless motor over brushed motors are high power-to-weight ratio, high speed, nearly instantaneous control of speed (rpm) and torque, high efficiency, and low maintenance.

4.4.1. BLDC motor Specifications:

Rated Voltage	:	24V DC
• Rated Power	:	350W
• Turn Potential	:	5V
• RPM (after reduction)	:	3300 rpm
• Rated current	:	19.5A
• Full load current	:	14.2A
• Current limiting protection	:	20A (amp)
Torque constant	:	9 Nm (90kg – cm)
• Torque stall	:	40Nm (400kg – cm)

4.4.2. Why we choose BLDC motor

There are several reasons why one might choose a Brushless DC (BLDC) motor over other types of motors like brushed DC motors or AC induction motors:

Efficiency: BLDC motors are more efficient than brushed DC motors because they eliminate the energy losses associated with brushes. This can result in lower energy consumption and reduced operating costs.

Longevity: Since BLDC motors don't have brushes that wear out over time, they tend to have longer lifespans and require less maintenance compared to brushed DC motors.

Better Control: BLDC motors offer better control over speed and torque compared to brushed DC motors. They can be controlled more precisely using electronic commutation, making them suitable for applications requiring fine-tuned performance.

High Power Density: BLDC motors typically have a higher power-to weight ratio compared to brushed DC motors, making them suitable for applications where space and weight are constraints.

4.5. Indication of State of Charge

The state of charge (SOC) of a lithium-ion battery is defined as the ratio of the remaining charge in the battery to the maximum charge that can be delivered by the battery. It is one of the most important states to be tracked in a battery. SOC is a decisive factor to ensure the stability and safety of the battery working state. charged.

There are different ways to determine the SOC of a lithium-ion battery some of them are

- Estimation of SOC using open circuit voltage method
- SoC estimation using coulomb Counting method
- Kalman Filter method

There are many ways to indicate the battery level of a vehicle, in our project we have chosen to use LED's. 5 LEDs are taken for the determination of battery level. The 5 LEDs are connected in series, the positive terminal of first LED is connected to negative terminal of the 2nd LED, likewise, all the 5 LEDs are connected. We have taken 4 4.7k ohms resistors for determining the battery level. The first resistor is connected to negative side of first LED. Likewise, all the resistors are connected to in between the 5 LED's. The other terminals of the resistors are connected to each other. A 15V Zener diode is connected to positive side of the LED. Two connecting wires are taken one for positive terminal, another for negative terminal, one of the wire is connected to the positive terminal of the Zener diode and the other wire is connected to the resistor end terminal.

ISSN: 3107 - 8605 (Online) , http://www.ijcser.com/ , Vol. 1 , Issue. 3 , 2024 , https://doi.org/10.63328/IJCSER-V1RI3P11

4.6. Implementing Voice Command Integration

We have implemented voice command integration by using Arduino. The components we have used for voice command integration are Arduino, Bluetooth module, two channel relay. The Bluetooth module pin VCC is connected to 5V pins of Arduino, the ground pin is connected to ground pin of Arduino, the RX pins is connected to TX pin of Arduino, The RX pin is connected to TX in of Arduino.

4.6.1 Program For Voice Command Integration:

```
#define start 2
#define bulb 4
void setup() {
// put your setup code here, to run once:
Serial.begin(9600);
pinMode(start, OUTPUT);
pinMode(bulb, OUTPUT);
}
void loop() {
// put your main code here, to run repeatedly:
if(Serial.available() == 1)
{
String val = Serial.readString();
Serial.println(val);
if(val == "start")
{
digitalWrite(start, HIGH);
}
if(val == "stop")
{
digitalWrite(start, LOW);
}
if(val == "bulb on")
{
digitalWrite(bulb, HIGH);
}
if(val == "bulb off")
{
digitalWrite(bulb, LOW);
}
if(val == "all on")
{
digitalWrite(start, HIGH);
digitalWrite(bulb, HIGH);
}
if(val == "all off")
{
digitalWrite(start, LOW);
digitalWrite(bulb, LOW);
}
}
}
```

4.7. MIT App Inventor

MIT App Inventor : (App Inventor or MIT AI2) is a high-level block-based visual programming language, originally built by Google and now maintained by the Massachusetts Institute of Technology. It allows newcomers to create computer applications for two operating systems: Android and iOS, which, as of 25 September 2023, is in beta testing. It is free and open source. Its target is primarily children and students studying computer programming, similar to Scratch. The web interface consists of a graphical user interface (GUI) very similar to Scratch and Star Logo, allowing users to drag-and-drop visual objects to create an application that can be tested on Android and iOS devices and compiled to run as an Android app. It uses a companion mobile app named MIT AI2 Companion providing live testing and debugging.

In our project we are developed an app for voice control, in order to create the app for voice control using Bluetooth, we have to set the layout according to the requirement. Later from the sensor's menu, clock is extracted to the layout, from media's menu speech recognizer is extracted to the layout and from connectivity's menu Bluetooth client is extracted to the layout.

4.8. GPS Tracking System

We have implemented GPS tracking System to our electric bicycle by using GPS module, GSM module and Arduino. GPS module is used to lock the satellite signals and collects the longitude and latitude of a location. The GPS module consist of a antenna to collect the location. The GSM module we used is 800L.The GSM module is used to send and receive the information to our mobile phone. A 2G sim is installed in GSM module, it sends and receive the Information

4.8.1. Program for GPS Module

```
#include <SoftwareSerial.h>
#define rxPin 8
#define txPin 9
SoftwareSerial gpsSerial(rxPin,txPin);
void setup()
{
//Begin serial communication with Arduino and
Arduino IDE (Serial Monitor)
Serial.begin(115200);
//Begin serial communication with Arduino and
SIM800L
gpsSerial.begin(9600);
Serial.print
ln("Initializing...");
delay(1000);
```

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```
}
void loop()
{
while (gpsSerial.available() > 0)
Serial.write(gpsSerial.read());
}
```

4.8.2 Program for GSM module:

```
#include <SoftwareSerial.h>
#define rxPin 2
#define txPin 3
SoftwareSerial sim800L(rxPin,txPin);
void setup()
{
//Begin serial communication with Arduino and
Arduino IDE (Serial Monitor)
Serial.begin(115200);
//Begin serial communication with Arduino and
SIM800L
sim800L.begin(9600);
Serial.println("Initializing...");
delay(1000);
}
void loop()
{
while(sim800L.available()){
Serial.println(sim800L.readString());
}
while(Serial.available()) {
sim800L.println(Serial.readString());
}
}
```

5. Results & Discussion

5.1. Strengths compared to existing Electric Bicycle:

Cost-effective: At 20,000 rupees, our design falls within a budget-friendly range compared to some high-end e-bikes that can reach several lakh rupees.

Decent Range and Speed: With a 20 km range and 20 kmph speed while carrying a 60 kg load, our electric bicycle caters to everyday commutes within city limits.

5.2. Positives of your project implementation

Voice control integration: This is a significant advantage! Voice control for starting and stopping the bike enhances convenience and safety, allowing riders to keep their hands on the handlebars. This feature is not yet common in all e-bikes, especially in the budget segment.

GPS integration: Having GPS provides valuable functionalities like navigation, tracking rides, and potentially anti-theft features GPS is another feature not universally available in all e-bikes, especially at a budget-friendly price point.

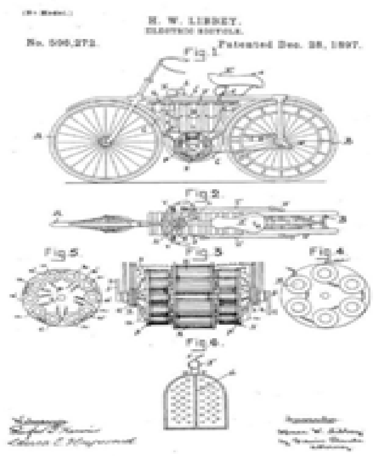

Figure 1. Picture of Patent Drawing for Electric Bicycle 1895

Figure. 2 Lithium-ion battery Pack

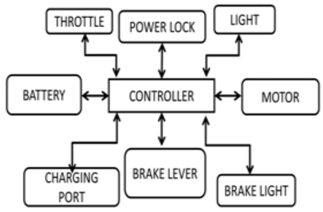

Figure. 3 Battery Management System

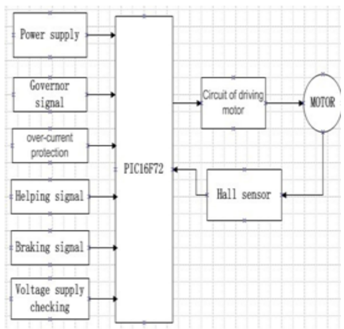

Figure. 5 Frame work of Controller

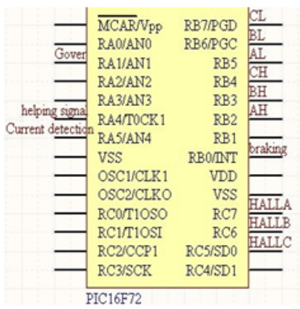

Figure 6. Main Control Chip of a controller

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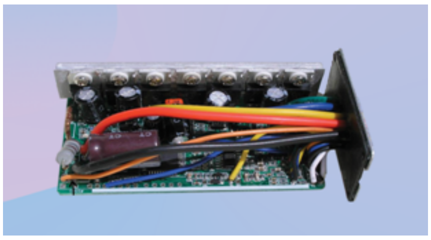

Figure 7. Inside part of a DC Controller

Figure 8. Installing DC Controller in Electric Bicycle

Figure 9. 24V BLDC Motor

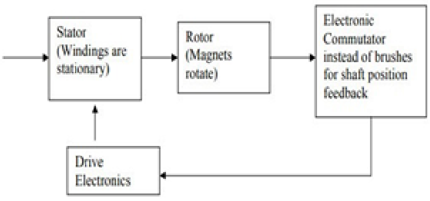

Figure 10. Block Diagram of BLDC Motor

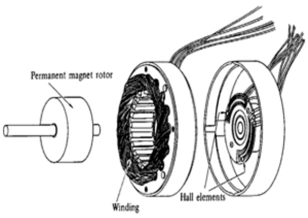

Figure 11. Structure of BLDC motor

Figure 12. Installing BLDC motor to Electric Bicycle

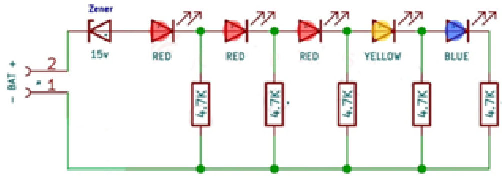

Figure 13. Indication of battery level

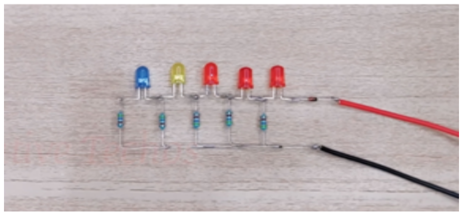

Figure 14. Indication of battery level using LED

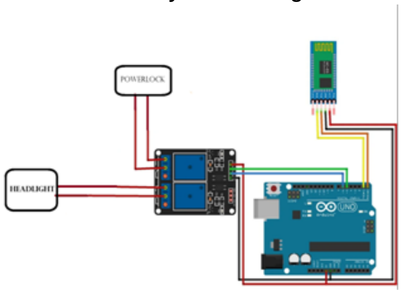

Figure 15. Block Diagram of voice command integration

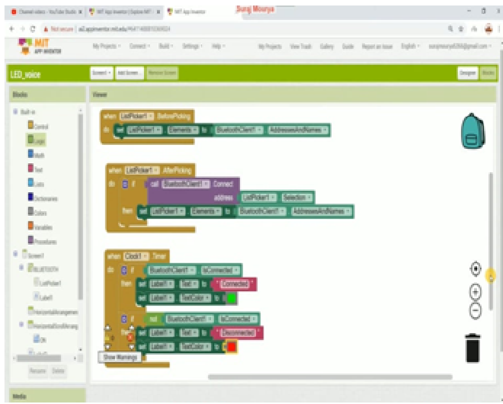

Figure 16. Block for Voice control App

Figure 17. Block for Voice control App

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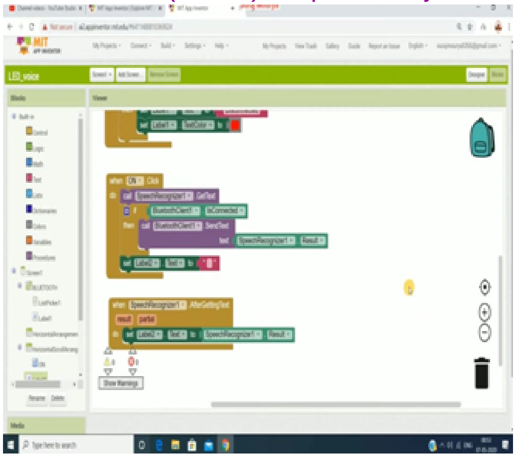

Figure 18. Block for Voice control App

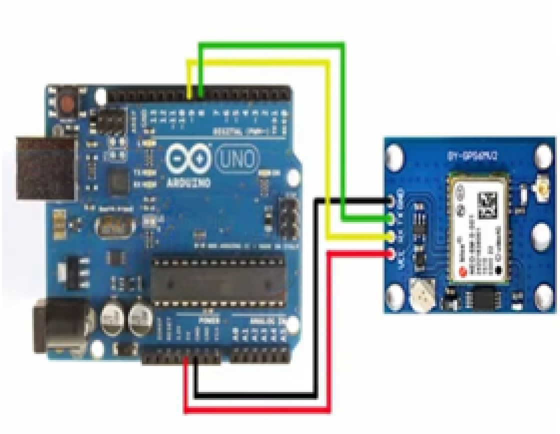

Figure 19. Block Diagram of GPS Module

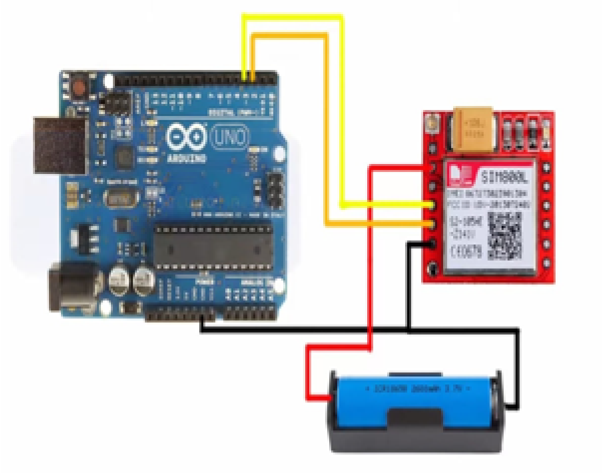

Figure 20. GSM module

Figure 21. Smart Electric Bicycle

Table. 1 Smart electric Bicycle vs Electric Bicycle

Feature	Smart Electric Bicycle	Electric Bicycle (EMotorad)
Motor	24V BLDC Motor, 350W	250W Rear HUB Motor
Battery	24V, 14Ah (336Wh)	36V 10.2 Ah lithium-ion
Controller	24V DC, manages motor, battery, throttle, charging, brakes	24V DC, manages motor and battery
Range	Up to 35km on a single charge	Up to 45km on a single charge
Top Speed	25km/h (may be limited by regulations)	25km/h (may be limited by regulations)
Charge Time	3 hours	4 hours
Special Features	* Voice control (power on) * GPS tracking	None
Price	₹22000	₹34999

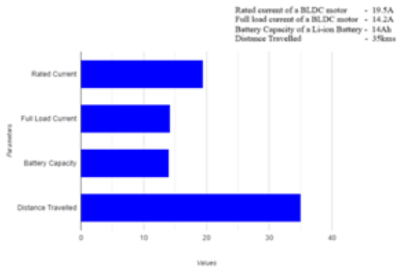

Figure 22: Bar graph of Electric bicycle specifications

6. Conclusion and Future Scope

Finally, the integration of voice command functionality into electric bicycles represents a significant advancement in the realm of smart and connected transportation solutions. This project has successfully enhanced the user experience, convenience of electric bicycles, paving the way for a more intuitive and accessible mode of urban mobility**.** In conclusion, the implementation of voice command functionality for starting and stopping electric bicycles represents a pivotal advancement in the domain of user interaction and safety within urban mobility solutions. By streamlining the essential functions of activation and deactivation through voice recognition technology, this project enhances the accessibility, convenience, and safety of electric bicycle operation, contributing to a more seamless and intuitive riding experience.

Enhancing Voice Recognition: Invest in advanced algorithms and machine learning techniques to improve

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voice recognition accuracy, robustness, and multilingual support.

Integration of IoT (Internet of Things): Implement IoT connectivity to enable remote monitoring of bicycle parameters, firmware updates, and data analytics for predictive maintenance.

Energy Harvesting Technologies: Explore the integration of energy harvesting technologies such as regenerative braking to improve overall energy efficiency and extend battery life.

User Interface Enhancements: Develop a user-friendly interface for the voice-controlled system, including visual and auditory feedback to enhance user interaction and safety.

Sustainable Materials and Manufacturing: Investigate the use of sustainable materials and manufacturing processes to reduce the environmental footprint of electric bicycles and promote eco-friendly transportation solutions.

Data Availability

Conflict of Interest: We do not have any conflict of interest.

Funding Source: None

Acknowledgements

We are very much thankful to our Guide **Mr. M LOKESH, MTech., Department of Electrical and Electronics Engineering,** for this valuable support and constant encouragement given to us during this work. Our sincere thanks to **Dr. S. RAMALINGA REDDY,** Director and the management **of ADITYA COLLEGE OF ENGINEERING, MADANAPALLI**, for providing excellent infra structure and lab facilities that helped as to go through the different areas of interest to do our project work Our privilege and pleasure to express our profound sense of respect, gratitude and indebtedness to **Dr. K. SATISH BABU, Principal** of the institution for guiding and providing facilities for the successful completion of our project work. We express our deep sense of gratitude to **Dr. L. VENUGOPAL REDDY, HOD** for supporting and encouraging at each stage of our Project work and guided us to do our best. Last but not least, we wish to acknowledge our parents and friends for giving moral strength and encouragement.

Declaration

We Declare with our best of Knowledge that this research work is purely Original Work and No third-party material Not used in this article drafting. If any such kind material found in further online publication, we are responsible only for any judicial and copyright issues.

References

[1]. Zhang, C., & Xu, J. (2020). Review on electric bicycle technology and research trends. International Journal of Sustainable Transportation Technology, 3(2), 39-45.

[2]. Yang, X., & Chen, H. (2019). Design and implementation of Battery Management System for electric bicycle based on STM32. Journal of Physics: Conference Series, 1236(4), 042027.

[3]. Zhao, M., Huang, H., & Sun, F. (2018). Research on the optimization of lithium-ion battery charging and discharging strategy in electric bicycle. IOP Conference Series: Earth and Environmental Science, 187(4), 042027

[4]. Wang, X., Liu, X., & Yang, W. (2021). Research on Battery Management System of lithium-ion battery pack for electric bicycle. IOP Conference Series: Earth and Environmental Science, 825(1), 012063.
Wu, J., & Chen, H. (2020). Design and implementation of lithium-ion Battery Management System for electric bicycle. IOP Conference Series: Materials Science and Engineering, 712(1), 012063.

[5]. Chen, Y., & Li, M. (2019). Research on the Battery Management System of lithium-ion battery for electric bicycle. IOP Conference Series: Earth and Environmental Science, 329(1), 012063.

[6]. Zhang, H., & Xiong, Y. (2018). A survey on Battery Management Systems for lithium-ion batteries of electric vehicles and bicycles. Journal of Power Sources, 396, 91-105.

[7]. The cycle is Here". Yanko Design. 29 August 2014. Retrieved 30 August 2020.

[8]. Hung, Nguyen Ba; Lim, Ocktaeck (2020). "A review of history, devel. Applied Energy. 260: 114323. doi:10.1016/j.apenergy.2019.114323

[9]. Stilo, Lorenzo; Segura-Velandia, Diana; Lugo, Heinz; Conway, Paul P.; West, Andrew A. (2021). "Electric bicycles, next generation low carbon transport systems: A survey". Transportation Research Interdisciplinary

[10]."Guide to e-bikes". Association of Cycle Traders. Accessed May 1, 2022. "Electrical bicycle". Retrieved 9 April 2020.

[11].J. C. Martin, D. Milliken, J. Cobb, K. McFadden, and A. Coggan, "Validation of a mathematical model for road cycling.pdf," Journal of applied biomechanics, vol. 14, pp. 276–291, 1998, issn: 1065-8483. [Online].

[12].Le, "Model Predictive Control for Sensor-Based Group Training Optimization in Professional Cycling," Proceedings of the European Control Conference 2009,

[13].T. Olds, "Olds (1998) - The mathematics of breaking away and chasing in cycling," European Journal of Applied Physiology and Occupational Physiology,

[14].W. Morchin, "Energy management in hybrid electric vehices," in 17th DASC.AIAA/IEEE/SAE. Digital Avionics Systems Conference. Proceedings (Cat.No.98CH36267), vol. 2, IEEE, 1998, pp. 1–6, isbn
M. Kampa and E. Castanas, "Human health effects of air pollution," Environmental Pollution, vol. 151, no. 2, pp. 362–367, 2008, issn: 02697491. doi:10.1016/j.envpol.2007.06.012 (cit. on pp. 8, 9).

[15]. Seaton, W. MacNee, K. Donaldson, and D. Godden, "Particulate air pollution and acute health effects.," Lancet, vol. 345, no. 8943, pp. 176–178, 1995.