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Dependable Safety and Cutting-Edge Security for Electric Motorcycles, Driven by Artificial Intelligence.

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Abstract - In response to the growing concerns over electric motorcycle theft and the lack of robust security systems, this project introduces a comprehensive software and security solution designed specifically for electric two-wheelers. The system integrates advanced features including intelligent power modes, a throttle lock, a GPS-based tracking system, an audible alarm, and a "Find My Bike" function, all aimed at enhancing security and improving user control. The intelligent power mode dynamically adjusts the motorcycle's performance based on terrain using an AI-powered control system, ensuring optimal efficiency and ride comfort. A core feature is the throttle lock, which electronically disables motor functionality when activated, preventing unauthorized movement. The GPS module provides real-time location tracking, while the alarm system is triggered by motion sensors to alert nearby individuals and deter theft. The "Find My Bike" feature helps users quickly locate their vehicle through the mobile application, which also provides real-time notifications, location history, and remote access to vehicle controls. The system stores essential information such as driver identity and vehicle registration, offering a secure and centralized data repository. Built on an embedded microcontroller platform, the system uses encrypted communication protocols for secure data transmission and supports over-the-air updates for continuous improvement. The mobile application, compatible with Android and iOS, serves as the primary user interface, offering full access to telemetry, security features, and user preferences. This project not only addresses current security limitations but also sets a foundation for smarter, safer electric mobility solutions through intelligent automation and connected technology.

Key Words: AI, Safety, GPS, Anti theft system

1. INTRODUCTION

Electric motorcycles and scooters are eco-friendly, plug-in electric vehicles equipped with two or three wheels. These vehicles are powered by rechargeable batteries that store electricity and drive one or more electric motors. While electric scooters feature a step-through frame for easy mounting, electric motorcycles are designed more like traditional bikes, integrating electric motors directly into the frame to assist with propulsion. As the electric vehicle (EV) industry rapidly evolves, artificial intelligence (AI) is becoming a crucial component in enhancing vehicle performance, safety, and user interaction. AI applications in the EV sector include smart navigation, user behavior monitoring, predictive maintenance, and even experimental self-driving functionalities. These technologies enable manufacturers to collect valuable data, perform advanced diagnostics, and improve overall vehicle reliability. Given the increasing popularity of electric motorcycles and the rise in vehicle thefts, there is a pressing need for advanced software and integrated security systems tailored to these modern vehicles. Our project addresses this need by developing a comprehensive security and control system that enhances the functionality and safety of electric motorcycles. The system incorporates key features such as a Global Positioning System (GPS), an alarm system, and a Smartphone-based throttle control. GPS tracking allows real-time monitoring of the motorcycle's location, making it easier to recover in case of theft. The built-in alarm system is triggered when unauthorized movement is detected, producing a loud alert to attract attention and deter potential thieves. A standout feature of our system is the throttle lock, which can be controlled through a dedicated mobile application. When activated, the throttle lock disables the motor's ability to engage, preventing the motorcycle from being moved or started. The mobile application serves as the central control hub for the vehicle's security features. It stores essential information such as the driver's identity, vehicle registration number, and other relevant data. Through the app, users can remotely activate or deactivate the throttle, monitor GPS data, and receive alerts if suspicious activity is detected. This integration of the Internet of Things (IoT) further enhances vehicle safety by enabling seamless communication between the motorcycle and the user. Additional functionalities include geofencing, which alerts the owner if the vehicle leaves a designated area, and system logs that keep a record of any attempted breaches or motion detection events. With fuel prices on the rise and environmental concerns growing, electric motorcycles offer a practical, energy-efficient, and cost-effective alternative to traditional fuel-powered vehicles. Promoting the use of electric motorcycles can significantly reduce emissions, contributing to a cleaner and more sustainable urban environment. Our project not only supports this green transition by improving vehicle security and user convenience but also enhances public trust in electric mobility solutions. The intelligent control and monitoring system we propose is a forward-thinking advancement that aligns with global trends in transportation, smart cities, and sustainability. By integrating AI, IoT, and smart control technologies, our system provides a much-needed layer of protection, control, and efficiency for electric motorcycle users, making it an essential contribution to the future of eco-conscious personal transportation [1][2][3].

2. PROPOSED SYSTEM

The proposed system introduces an advanced electric motorcycle that integrates remote manual and autonomous operation capabilities. Designed with modern technology and smart features, the vehicle can be controlled from a distance,

either by human input or through automated systems. Furthermore, the motorcycle's real-time location and performance metrics can be continuously monitored using a dedicated mobile application. This combination of features enhances both the convenience and safety of motorcycle use while contributing to the broader adoption of electric mobility solutions. [1][2][3][4][5]

The core functionalities embedded in this system include:

- Remote Vehicle Control
- Real-Time Location Tracking
- Live Performance Monitoring
- Regenerative Braking System

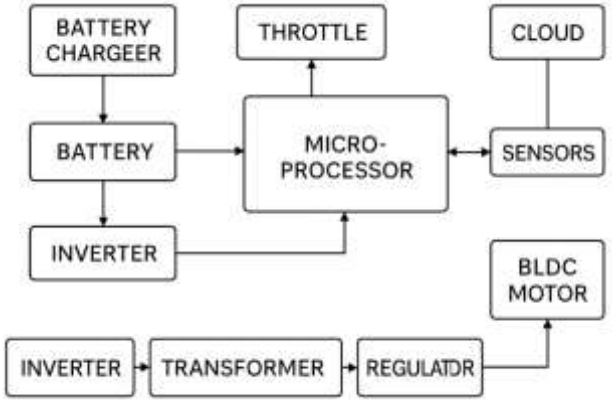

Fig: Block Diagram representation of the proposed system

2.1 Remote Vehicle Operation

The ability to remotely control the motorcycle adds a layer of convenience and practicality. Through the mobile app or another user interface, the vehicle can be moved without the rider physically being present. This functionality is particularly useful in scenarios such as smart parking systems, automated delivery services, or repositioning the motorcycle in tight or hazardous spaces. The user can send commands to start, stop, accelerate, or change the direction of the vehicle from a distance, enabling a semi-autonomous interaction with the vehicle

2.2 Real-Time Location Tracking

To support effective monitoring and security, a GPS module is integrated into the system. This module constantly communicates the precise location of the motorcycle, allowing users to track its movement via the mobile application. GPS data is provided in the NMEA format, a standard protocol for GPS communication, ensuring compatibility with mapping and tracking software. The recorded location data can be stored in a cloud-based or local database, which allows historical tracking and route analysis. This is a crucial feature for logistics, fleet management, and anti-theft protection.

2.3 Live Performance Monitoring

Another vital aspect of the system is the continuous monitoring of the motorcycle's operational metrics. This includes battery level, speed, motor temperature, and overall system health. All these parameters are gathered in real-time and transmitted to the user's mobile application, giving riders and operators immediate insights into vehicle status. Early warnings for maintenance or system malfunctions can also be incorporated into the app's functionality. This ensures that potential issues can be addressed before they lead to breakdowns or safety concerns.

2.4 Regenerative Braking System

The motorcycle design also includes a regenerative braking mechanism. In this system, the energy usually lost during braking is instead captured and converted back into usable electrical energy, which is stored in the battery. This not only improves the energy efficiency of the vehicle but also extends the operational range on a single charge. Regenerative braking is a hallmark of modern electric vehicles and aligns with the system's sustainable and energy-conscious goals

The main components' of the proposed system are

- Sensor-Based Speed Control and Core Components
- Main Control Unit: Raspberry Pi 4
- Supporting Microcontroller: Arduino
- GPS Module
- Motion and Orientation Sensors
- Relays as Electronic Switches

2.5 Sensor-Based Speed Control and Core Components

Speed and movement control in the system are achieved using a variety of sensors and electronic modules that collect and process data from the environment and the vehicle's internal systems.

2.6 Main Control Unit: Raspberry Pi 4

At the center of the control architecture is the Raspberry Pi 4, a powerful yet cost-effective microprocessor. It functions as the brain of the motorcycle, responsible for processing commands, collecting data from sensors, handling remote control operations, and managing Internet of Things (IoT) connectivity. Raspberry Pi is a single-board computer built around an ARM-based processor. It features more than 26 General Purpose Input/Output (GPIO) pins, making it suitable for interfacing with multiple sensors and modules. Due to its affordability, modularity, and open-source support, it is widely used in prototyping and development of embedded systems.

2.7 Supporting Microcontroller: Arduino

In conjunction with the Raspberry Pi, an Arduino board is also used. Arduino is an open-source electronics platform based on easy-to-use hardware and software. It supports both analog and digital inputs and outputs, and is programmable via the Arduino IDE using C or C++. This microcontroller handles tasks such as interpreting sensor inputs and executing specific control functions. Arduino boards are favored in embedded systems and automation due to their reliability and community support.

2.8 GPS Module

The GPS module is responsible for delivering the motorcycle's geographical coordinates. It outputs data in the NMEA format, which includes information such as latitude, longitude, altitude, and speed. This data is used for both live tracking and logging the travel history of the vehicle, making it essential for navigation and security applications

2.9 Motion and Orientation Sensors

To enhance movement control and stability, two types of motion sensors are used:

- Accelerometer: Measures linear acceleration in different axes, enabling the system to understand how fast the motorcycle is moving or changing direction.

- Gyroscope: Detects orientation and angular velocity, helping to stabilize the vehicle and determine its tilt or rotation. These sensors are commonly used in aerospace and marine navigation and have been adapted here to improve vehicle dynamics and autonomous navigation.

2.10 Relays as Electronic Switches

Electronic relays play a crucial role in this system as they act as electronically controlled switches. When a low-power signal is applied, the relay activates an internal solenoid that opens or closes a circuit, just like a mechanical switch. They are available in various current ratings and are essential for isolating control signals from high-power circuits, thereby improving safety and control flexibility.

This innovative electric motorcycle system combines smart technology with sustainable transportation. By incorporating remote and autonomous operation, live tracking, performance diagnostics, and energy-efficient braking, it promises a highly functional and user-friendly experience. The integration of Raspberry Pi, Arduino, GPS, and various sensors ensures robust performance, scalability, and adaptability for future enhancements in the field of electric mobility.

3 METHODOLOGY

An electric bike relies on a Brushless DC (BLDC) motor as its main driving component. This type of motor is known for its efficiency, reliability, and reduced maintenance compared to traditional brushed motors. To control and monitor the overall operation of the bike, a Raspberry Pi 4 microprocessor is employed. Acting as the central processing unit, it manages all intelligent operations, including Artificial Intelligence (AI) and Internet of Things (IoT) features, making it the core of the system. The intelligent electric bike consists of several essential components: the BLDC motor, a motor controller, the Raspberry Pi microprocessor, cloud storage infrastructure, and a lithium-ion battery pack. The BLDC motor propels the vehicle and is managed by a dedicated motor controller, which includes a six-phase variable frequency inverter and an embedded microcontroller. This setup also incorporates PID (Proportional-Integral-Derivative) control to optimize motor performance. Hall effect sensors within the motor continuously send position feedback to the controller. This feedback enables the controller to send precise Pulse Width Modulated (PWM) signals to the inverter, which in turn controls the motor's rotation. The motor controller receives inputs from the throttle, brake sensors, and other onboard modules, allowing it to respond dynamically to various driving conditions. Meanwhile, the Raspberry Pi microprocessor sends commands to the motor controller for both manual and automated operation. Communication between the microprocessor and motor controller is bidirectional—the microprocessor gathers data from the controller for system monitoring and performance analysis, while the controller utilizes data from the processor to fine-tune motor behavior and speed. To enhance safety and automation, the Raspberry Pi is also linked to a camera module. It runs a machine learning model capable of detecting obstacles, enabling real-time object avoidance and automatic braking based on image analysis. This vision-based AI system improves the bike's autonomous functionality. For data storage and remote connectivity, the system integrates cloud storage using Firebase, a real-time cloud database. This allows both the user and the vehicle to store and retrieve data, such as trip logs, performance metrics, and system alerts. Companions mobile application is used to view, edit, and manage this data remotely, providing seamless remote monitoring and control. Relay modules are implemented throughout the vehicle to control key components, including the motor, headlights, turn indicators, high-level brake lights, and other electrical subsystems. These relays act as switches, triggered by control signals from the microprocessor. Powering all of these components is a lithium-ion battery pack, which is known for its high energy density and long cycle life. The battery supplies energy not only to the motor but also to the microprocessor, sensors, and auxiliary devices. Different voltage requirements across components are addressed using buck converters. For instance, the Raspberry Pi operates at 5V, lighting systems at 12V, and the BLDC motor at a significantly higher voltage level, depending on the design. This integration of electric propulsion, intelligent control, cloud connectivity, and safety mechanisms makes the bike a robust, smart electric vehicle suited for modern urban commuting. [2][3][4][5][6]

4 CONCLUSION

An electric motorcycle is a two-wheeled vehicle powered entirely by an electric motor, offering a clean, efficient, and environmentally friendly mode of transportation. Unlike conventional motorcycles that rely on internal combustion engines, this vehicle produces zero emissions, contributing significantly to reducing air pollution and dependence on fossil fuels. One of the key advantages of an electric motorcycle is its exceptionally low running cost per kilometer, making it an economical choice for daily commuting. In addition to being eco-friendly and cost-effective, this electric motorcycle is designed with advanced safety and security features. It includes a real-time tracking system that enables users to monitor the exact location of the bike at any given moment. This live tracking capability enhances security, allowing users to trace the bike's movement in case of theft or unauthorized use. Furthermore, the system integrates an alarm feature that triggers alerts under suspicious conditions, providing an additional layer of protection against theft and tampering. To further improve energy efficiency, the motorcycle supports regenerative braking technology. This mechanism recovers kinetic energy during braking and converts it into electrical energy, which is then fed back into the battery. As a result, the overall energy management system of the vehicle becomes more efficient, extending the range and reducing the need for frequent charging. The motorcycle can also be remotely controlled and monitored via a custom-developed mobile application. This app acts as the central interface between the user and the bike. Through the app, users can access key information such as the vehicle's current status, lock or unlock the bike remotely, and view real-time location updates. The app's intuitive design ensures that users can manage their electric motorcycle conveniently from their smart phones, enhancing both usability and security.

In summary, this electric motorcycle combines green energy, intelligent control, and robust safety features into a single, modern transportation solution that is practical, affordable, and sustainable for urban mobility.

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