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IoT-Driven Intelligent Monitoring Framework for Bikes

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Abstract: The Smart Bike Monitoring System uses IoT since it is an advanced solution incorporating Internet of Things (IoT) technology into two-wheelers to improve safety, performance, and environmental awareness. Various sensors as well as devices are integrated within the system to collect real-time data. This data comes directly from the bike and from its surrounding environment. Actionable perceptions get generated, faults become detected, also key performance metrics get monitored while this data is processed as well as analyzed for optimizing bike usage. The system is remaining continuously connected to the internet for use. Therefore, a web interface or mobile application lets bike owners monitor their vehicle remotely. The car follows lanes is a core feature plus automatic brakes prevent accidents plus real-time accident and emergency alerts are sent plus the car detects engine smoke/emission plus headlights activate automatically in dense fog plus real-time alerts and notifications are delivered. This thorough IoT-based solution does greatly improve rider safety vehicle efficiency and environmental responsibility.

Keywords: IoT, Blynk, Smart Bike, GPS, ThingSpeak, Node MCU, Real-Time Monitoring, then Vibration Sensor.

I. Introduction:

In recent years, bicycles have gained significant popularity as a sustainable and efficient mode of transport, especially in urban and semi-urban areas. However, with this increased usage comes a rise in security concerns, such as theft, misuse, and lack of real-time monitoring. Traditional security methods like physical locks are often insufficient, and users have no way to monitor the status or location of their bicycles remotely. To address these challenges, Bike Security Monitoring Systems integrated with Internet of Things (IoT) technology have emerged as a modern solution.

These systems use a combination of sensors (like GPS, vibration, and motion detectors), microcontrollers, and wireless communication to create a smart, connected bike. They provide features such as real-time location tracking, theft detection, unauthorized movement alerts, and environmental condition monitoring. By connecting the bike to a cloud platform or mobile application, users can receive instant notifications, track their bike remotely, and access historical data for analysis.

The goal of such a system is not only to deter theft and misuse but also to promote safer and smarter cycling practices through advanced technological support. Urban transportation is evolving with the integration of smart technologies. While vehicles like cars and motorcycles have embraced advanced electronics, bicycles remain underutilized in the smart mobility space. With increasing theft incidents and the need for real-time analytics, a smart system can transform traditional bicycles into intelligent assets.

This paper explores an IoT-based system that provides live tracking, theft alerts, and parameter monitoring to improve the efficiency and security of bicycles. This paper/project explores the design and implementation of an IoT-based bike security monitoring system that is affordable, scalable, and easy to use, aiming to improve personal transportation safety and enhance user experience.

II. Literature Survey:

Several studies have explored the use of IoT in vehicle monitoring systems, primarily focusing on cars and motorcycles. These systems often integrate GPS and GSM modules for real-time tracking and alert generation. However, their application in bicycle security is still emerging.

Recent projects have demonstrated the use of microcontrollers like NodeMCU or ESP32 with sensors such as GPS, vibration detectors, and temperature sensors to monitor bike status. Platforms like Blynk and ThingSpeak have been used to visualize data and send alerts via smartphones. While these systems show potential, they often lack features like environmental monitoring, speed tracking, and efficient power management.

A. Chandra Shreyas et al. (2018) designed a smart system that can detect vehicle theft and identify the driver using IoT technology. It uses GPS to track the vehicle, GSM to send alerts, and a camera to capture images of the person trying to access the vehicle. This helps in locating the vehicle and identifying intruders quickly.

Ameen (2020) developed a smart bicycle safety and tracking system using GPS and GSM. This system not only helps in tracking the bicycle's location but also sends alerts during emergencies. It improves safety for the rider and makes it easier to find a lost or stolen bike.

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Brijet et al. (2017) created an anti-theft system that uses fingerprint recognition. This system ensures that only the authorized person can start the vehicle, making it very difficult for thieves to steal it.

Mustafa et al. (2020) came up with a system that can detect and prevent vehicle theft using GPS and GSM. It constantly tracks the vehicle and alerts the owner if someone tries to break in. This system is especially useful in cities where vehicle theft is common.

Sadhukhan et al. (2017) made a security system for cars that uses fingerprints and IoT. It also includes GPS tracking and sends alerts to the owner. This system provides both location updates and secure access control.

Sahoo and Rath (2013) suggested a method to track a vehicle using GPS and GSM combined with mobile phones. Although it was mainly designed for cars, the same idea can be used for bikes too. The system gives real-time location with good accuracy.

Samsuri and Ambia (2017) designed an alarm system for motorcycles. It uses GPS and GSM to send alerts and includes sensors that detect shocks or vibrations. If someone tampers with the bike, the system calls or texts the owner immediately.

III. Methodology:

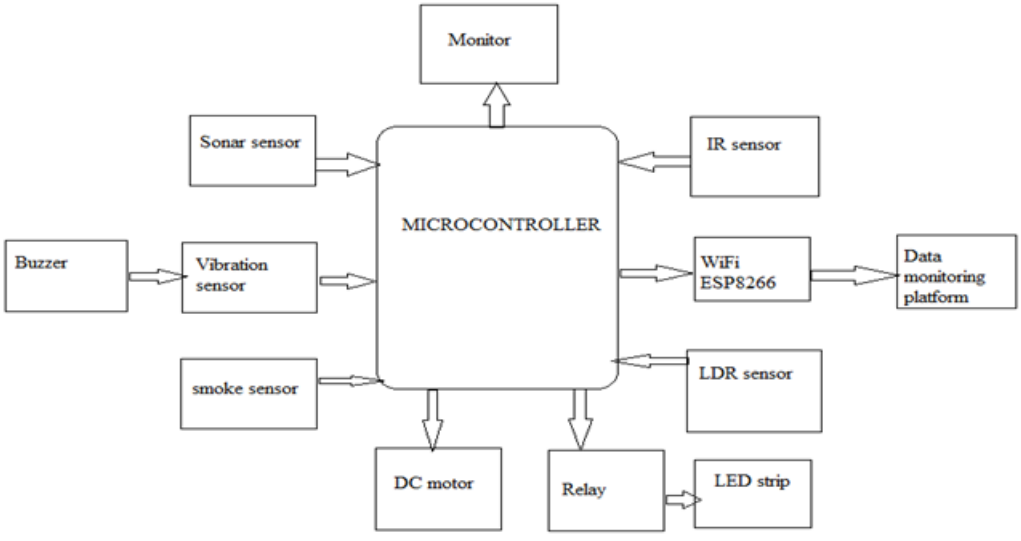
The Bike Security Monitoring System is built using an IoT-enabled microcontroller (Node MCU/ESP32) connected to sensors such as GPS, vibration, temperature, and speed sensors. These sensors collect data in real-time to monitor the bike's location, detect unauthorized movement, and track environmental conditions. The microcontroller processes the sensor data and transmits it via Wi-Fi to an IoT platform like Blynk or ThingSpeak, where it is displayed on a mobile app or web dashboard. If unusual vibration is detected, the system triggers a buzzer and sends an instant alert to the user's smartphone. The system is lightweight, affordable, and designed for easy integration onto any standard bicycle.

A smoke sensor monitors the emission levels; if the smoke exceeds normal limits, it indicates that the vehicle requires servicing. An ultrasonic sensor is employed for auto-braking by detecting obstacles in front of the vehicle, typically mounted on the bumper, and triggering the brakes to prevent collisions. Vibration sensors are implemented for collision detection; they instantly sense abnormal vibrations during an impact and respond by activating a buzzer to alert the rider. Infrared (IR) sensors are used to maintain lane discipline; they detect deviations from the intended path and send signals to the DC motor to slow down the vehicle and issue a warning. LDR sensors detect low-light conditions and automatically turn on the vehicle's headlights through a relay module, improving visibility and safety—particularly during foggy conditions. All sensor data is processed by a microcontroller (e.g., Arduino) using embedded C programming and is monitored in real-time. The data is also transmitted via the ESP8266 Wi-Fi module to the ThingSpeak IoT platform, enabling remote access, monitoring, and notifications through web interfaces. This integration offers an intelligent system that combines preventive safety, environmental awareness, and user connectivity.

System Description:

The Smart Bike Monitoring System is an innovative integration of Internet of Things (IoT) technology with embedded systems to provide a comprehensive solution for real-time safety, monitoring, and maintenance of two-wheeled vehicles. As modern transportation demands more intelligent and secure vehicles, this system aims to address critical areas such as accident prevention, environmental compliance, theft detection, and rider assistance. At the heart of the system is a microcontroller (e.g., Arduino or similar platform), which acts as the central processing unit. It is responsible for receiving, processing, and acting upon data collected from a series of onboard sensors. The system architecture includes both input devices (sensors) and output devices (actuators and indicators), forming a closed-loop system for dynamic feedback and control**.**

Block Diagram:



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Sensor Inputs and Their Functions

- Smoke Sensor: This sensor detects the level of smoke or harmful gases emitted from the bike's exhaust. Excessive smoke levels indicate that the bike may require servicing, thus promoting regular maintenance and environmental awareness. The data is processed to alert the rider or service team in real-time.
- Ultrasonic Sensor: It is used primarily for obstacle detection and automatic braking. Mounted on the front of the bike, it continuously measures the distance between the bike and objects ahead. If an object is detected within a critical distance, a signal is sent to either slow down or stop the bike using a DC motor or braking mechanism, effectively reducing collision risks.
- Tilt Sensor: The tilt sensor helps in accident or fall detection. It measures the angular movement of the bike. If the angle exceeds a certain threshold (indicating a fall), the system activates a buzzer to alert the rider and nearby individuals. This feature can also be linked with emergency alert systems for critical cases.
- Vibration Sensor: This sensor is used to detect sudden shocks or vibrations that may occur during an accident or theft attempt. It offers a quick and accurate response, especially when combined with the buzzer, to notify the user of unexpected activity.

Actuation and Alerts

All the sensor inputs in the Smart Bike Security System are interfaced with a microcontroller, which is programmed using Embedded C**.** The microcontroller processes this data in real time and executes predefined logic to respond to various events appropriately.

Based on the sensor inputs and system logic, the microcontroller controls several output devices:

- **Buzzer**: This provides immediate audio alerts in situations such as accidents, smoke detection, or theft attempts. It helps in drawing attention and acts as a deterrent against unauthorized activity.
- **DC Motor**: The motor is controlled to reduce speed or apply braking when required. For example, when the ultrasonic sensor detects an obstacle or when the IR sensor identifies lane deviation, the microcontroller reduces speed to prevent accidents.
- **Smoke Sensor**: When high pollution or smoke is detected, the system logs the event for environmental monitoring. This data is also sent to the cloud for remote access.
- **Tilt or Vibration Sensor**: In case the bike is tampered with or moved without permission, this sensor activates the buzzer immediately to warn the owner and surrounding individuals.
- **Ultrasonic Sensor**: This sensor is used to detect obstacles in the bike's path. If an object is detected within a certain range, the microcontroller responds by reducing the speed of the vehicle.
- **Infrared (IR) Sensor**: The IR sensor plays a critical role in lane-following and lane-deviation detection. If the bike strays out of its lane or off the road, the sensor identifies this deviation. In response, the microcontroller can either reduce the bike's speed or activate a warning signal, promoting better lane discipline and increasing rider safety. The microcontroller also controls the monitor**,** which provides a real-time display of essential system parameters such as speed, obstacle distance, light intensity, and sensor status. This feature enhances user interaction, situational awareness, and riding experience.
- **LDR (Light Dependent Resistor) Sensor**: This sensor manages the bike's automatic headlight system. It continuously checks ambient light levels, and when darkness or fog is detected, it triggers a relay to switch on an LED strip, ensuring visibility in poor lighting conditions and helping to prevent accidents.
- **LED Strip**: Acts as the bike's headlight, automatically turned on and off based on data from the LDR sensor, improving safety during night riding or low-light situations.

Processing and Control Unit

Relay Module: The relay module is used to activate lights or other high-power electrical components based on signals from the microcontroller. It ensures safe and efficient operation of devices like the headlight system**.**

Connectivity and Remote Monitoring

To expand system capabilities beyond local alerts and displays, the Smart Bike Security System integrates wireless communication and IoT features**.** The system uses ThingSpeak**,** a powerful cloud-based IoT analytics and visualization platform. Sensor data such as air pollution levels, vibration alerts, obstacle proximity, and light intensity is uploaded in real time. ThingSpeak provides graphical dashboards that allow users to monitor and analyze data remotely via a web browser or mobile

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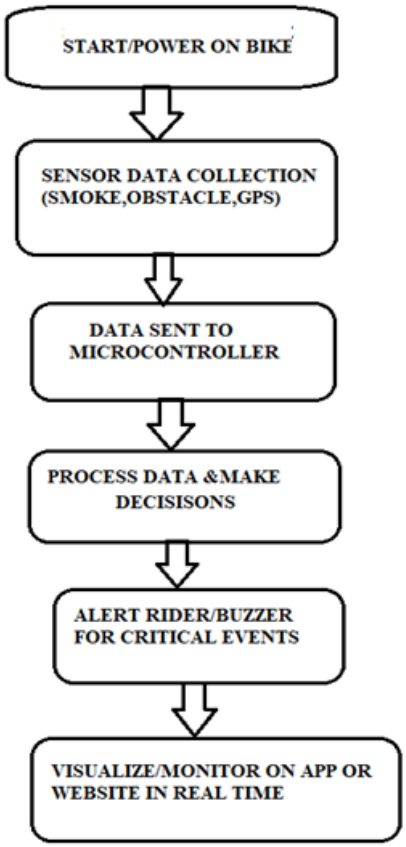
application. This empowers the user to track environmental conditions and system status even when away from the vehicle. To enable this wireless data transmission, the system includes a Wi-Fi module (ESP8266)**.** This module connects the microcontroller to the internet, allowing the bike to send sensor data continuously to the cloud. This setup not only provides remote monitoring and real-time alerts but also supports data-driven decision-making for improved safety, maintenance, and performance tracking.

IV. Flowchart



V. Results:

The Smart Bike Security System was successfully implemented and tested on a prototype model. The system included components such as a GPS module for location tracking, an RFID reader for owner authentication, a vibration/tilt sensor for unauthorized movement detection, and a GSM module for real-time alerts. Upon testing, the system demonstrated the following outcomes:

- **Accurate Location Tracking:** The GPS module provided real-time location data with minimal error, enabling efficient bike tracking.
- **Immediate Theft Alerts:** The GSM module successfully sent SMS alerts to the owner's registered number when unauthorized movement or tampering was detected.
- **Owner Verification:** The RFID system restricted ignition unless the authorized RFID tag was used, effectively preventing unauthorized access.
- **Remote Monitoring:** Integration with a cloud platform (such as ThingSpeak or Blynk) allowed real-time status updates and historical data monitoring from a smartphone or web dashboard

VI. Conclusion:

The Smart Bike Security System using IoT offers a significant enhancement over traditional locking systems. It provides **multi-layered protection** through real-time alerts, GPS tracking, and secure authentication. By combining IoT technology with embedded hardware, the system effectively addresses the rising issue of bike theft. Additionally, its modular design allows for future expansions, such as integration with smart helmets, accident detection, or environmental sensors.

In conclusion, this system demonstrates a practical and efficient solution for improving bike security and user peace of mind. With further optimization and miniaturization, it holds potential for commercial application in the personal and rental bike sectors. This project has a good real-life scope, if it is implemented by the government. It can help to reduce lot of road accidents

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of two wheelers as it is the major cause of deaths in the whole world. It can also help to prevent the damage occurred to the vehicles by the accidents. So, this helps in curbing the road accidents by implementing the Helmet protection and detection of alcohol content during the starting on of the bike.

This project here is undertaken keeping in view of traffic the traffic rules and also the safety of people. Implementation of this type of project by the government saves a lot of time for the traffic police and most importantly saves the precious life of a person as one cannot run a motor vehicle once he is drunk and if the helmet is not present

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