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Smart Helmet System: An IOT-Based Safety and Security Solution

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Abstract: The Smart Helmet system is an IoT-enabled solution designed to enhance road safety, prevent vehicle theft, and detect fuel pilferage. It integrates multiple technologies including biometric authentication, ignition control, real-time fuel monitoring, and mobile access to ensure vehicle operation only by authorized users wearing the helmet. The system uses a fingerprint scanner for rider verification, a sensor for helmet detection, and a fuel sensor to monitor fuel levels. It is connected to a mobile application that allows real-time alerts and remote ignition control. This multifunctional approach aims to enforce helmet usage, prevent unauthorized vehicle use, and rotect against fuel theft, promoting safer and smarter transportation

I. INTRODUCTION

Road traffic injuries and vehicle-related crimes are rising concerns, particularly involving two-wheelers. A significant portion of accidents involves riders not wearing helmets. Additionally, vehicle theft and fuel pilferage contribute to financial and security issues. Current preventive methods are mostly reactive or non-integrated. The Smart Helmet system offers a proactive and holistic solution. It combines biometric access control, helmet usage enforcement, real-time fuel monitoring, and mobile integration into one IoT-based system. The rider must wear the helmet and authenticate via fingerprint before ignition is enabled. A mobile application provides alerts and remote vehicle control. The system is designed to be cost-effective, scalable, and user-friendly, suitable for both individual users and fleet operators.

II. LITERATURE REVIEW

Various technologies have been explored to improve vehicle safety and security. Kumar et al. (2019) [1] implemented an alcohol-detection helmet with GSM alerts but did not include access control. Singh and Verma (2020) [2] developed an accident detection system with GPS alerts but lacked real-time access control or fuel monitoring.
Choudhary et al. (2021) [3] created a fingerprint-based ignition system, yet it didn't enforce helmet use or integrate theft detection. Fuel theft detection systems such as those by Bhattacharya and Jain (2022) [4] used fuel sensors but lacked mobile alert systems.
These systems address individual problems but are fragmented. Our project integrates all these features, helmet detection, biometric authentication, fuel theft monitoring, and mobile communication into a single smart system [5-7].

III.METHODOLOGY

The project was developed in the following phases:

A. Requirement Analysis

Defined key objectives—enforcing helmet use, enabling biometric access, preventing fuel theft, and providing mobile control.

1) System Design

Designed the system using a block architecture:

- Input: Helmet sensor, fingerprint scanner, fuel sensor
- Processor: ESP32 microcontroller
- Output: Ignition relay, mobile notifications
- Communication: Wi-Fi (to Firebase)

2) Component Selection

- ESP32 for processing and connectivity
- IR or pressure sensor for helmet detection
- R307 fingerprint sensor for biometric input

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- Fuel level sensor (ultrasonic or float-based)
- Relay to control ignition
- Android app using MIT App Inventor with Firebase for real-time updates

3) Software Development

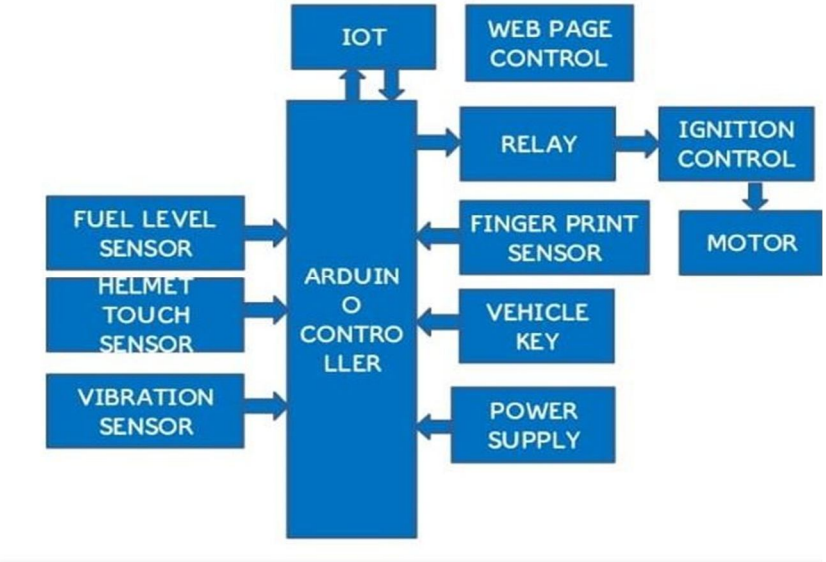
The ESP32 was programmed using Arduino IDE. Firebase handled real-time database communication. The mobile app allowed users to receive alerts and control ignition remotely.

4) System Integration & Testing

All modules were integrated and tested under multiple conditions:

- No helmet or failed fingerprint blocked ignition.
- Verified fingerprint and helmet allowed ignition.
- Sudden fuel loss triggered theft alert.
- Remote lock/unlock tested via mobile app.

B. Block diagram



IV. RESULTS

The Smart Helmet system prototype functioned as intended:

1) Helmet Detection: Ignition blocked if helmet not worn.
2) Fingerprint Auth: Ignition only allowed after successful verification.
3) Fuel Theft Detection: Sudden fuel drops while idle triggered alerts.
4) Mobile Control: Users received notifications and could lock/unlock ignition remotely.

All features worked reliably in testing. Power consumption remained within acceptable levels, and Wi-Fi latency for Firebase updates was minimal. The mobile app was responsive and intuitive, improving user experience.

V. CONCLUSION

The Smart Helmet system effectively combines road safety enforcement, biometric authentication, and fuel theft prevention into a unified IoT platform. It offers a reliable, real-time solution for vehicle owners to prevent unauthorized use and theft, and to ensure safer driving practices. By integrating sensors, microcontrollers, cloud services, and mobile apps, this system provides an innovative approach to modern vehicle safety challenges. Future upgrades can include GPS tracking, accident detection, and AI-based behavior analysis for advanced safety features.

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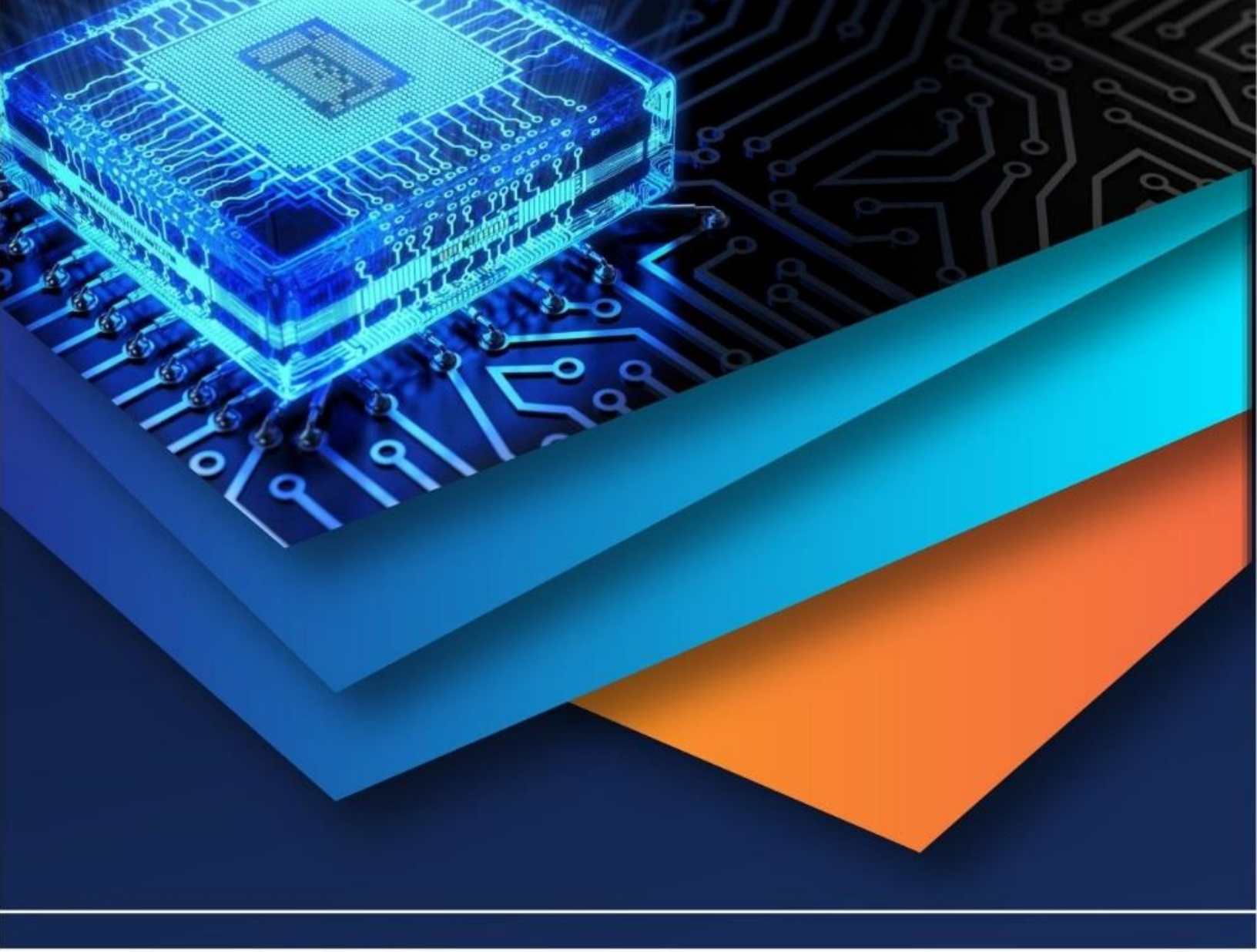

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