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HELMET ALERT: HELMET DETECTION SYSTEM

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ABSTRACT

This project presents a helmet detection system aimed at enhancing rider safety on two-wheelers using Internet of Things (IoT) technology and real-time object detection. The proposed solution, HelmetAlert, detects whether the rider is wearing a helmet by continuously capturing images via a camera module. If the system detects the absence of a helmet, it initiates a beep sound or disables the vehicle's engine to prevent the rider from proceeding without proper safety gear. Implemented using an Arduino or Raspberry Pi, along with a camera module, HelmetAlert leverages machine learning algorithms for accurate helmet detection. This paper surveys the design, methodology, and results of the HelmetAlert system, discussing its implications on safety and feasibility.

Keywords: Helmet Detection, Iot, Road Safety, Two-Wheeler Compliance, Real-Time Object Detection, Embedded Systems, Raspberry Pi, Arduino.

I. INTRODUCTION

In recent years, road safety has emerged as a critical public concern worldwide, especially in densely populated regions with high two-wheeler usage. Head injuries due to the non-use of helmets significantly contribute to the fatality and severity of accidents involving motorcycles and scooters. Governments and traffic authorities encourage helmet usage through laws and safety campaigns; however, compliance remains a challenge, often due to personal negligence or the absence of enforcement mechanisms.

The emergence of the Internet of Things (IoT) and advancements in computer vision technology have opened new possibilities for real-time, automated monitoring systems. These innovations offer a proactive approach to enforcing safety protocols, such as helmet use, by directly interacting with vehicle operation mechanisms. This project aims to design and implement an IoT-based Helmet Detection System—'HelmetAlert'—that automatically identifies whether a two-wheeler rider is wearing a helmet. If no helmet is detected, the system can activate warnings (such as a beeping sound) or even cut off engine power to encourage compliance with safety regulations.

HelmetAlert utilizes a camera module to capture images or video of the rider, with an Arduino or Raspberry Pi functioning as the primary processing unit. Through object detection algorithms, the system can analyse visual input in real-time to determine the presence or absence of a helmet. This approach leverages low-cost hardware components and open-source libraries, making the system not only scalable but also accessible for broader implementation. In this survey, we review existing literature on helmet detection, IoT-based road safety systems, and the use of embedded devices in object detection, with the goal of positioning HelmetAlert as an innovative solution to enhance rider safety.

II. METHODOLOGY

A. System Design:

The HelmetAlert system is designed to function as a self-contained IoT solution, integrated directly onto a two-wheeler. The main components include:

1. Camera Module: Mounted near the vehicle's speedometer or handlebars, positioned to continuously monitor the rider. Its placement ensures a clear view of the rider's head area, where the helmet should be present. The camera should be capable of capturing clear images or videos under various lighting conditions.

2. Processing Unit (Arduino or Raspberry Pi): This device processes incoming image data, running the object detection model to identify if a helmet is present. Given its computational requirements, a Raspberry Pi may be

preferred as it supports advanced image processing, though some low-power implementations with Arduino might be possible.

3. Alert/Control Mechanism: Actuators or relays are connected to the IoT device to perform actions if a helmet is not detected. For example, the device can control a buzzer for auditory alerts or interface with the ignition system to cut off engine power, ensuring the rider cannot operate the vehicle without a helmet.

B. Image Capture and Processing:

This step is crucial for providing high-quality input data to the object detection model:

1. Image Capture: The camera captures images at a defined interval (e.g., every second) or can continuously record a video feed when the engine is on. The frame rate and resolution should be optimized to balance clarity with processing load, aiming to capture the rider's upper body in each frame.
2. Image Preprocessing: The captured images are pre-processed before they are fed into the model. This includes steps like resizing, normalization, or adjusting for lighting to ensure uniform input quality for the object detection algorithm.
3. Edge Processing: Given the limited resources on an IoT device, efficient processing is necessary. Lightweight models or custom optimizations, like reduced resolution or frame skipping, may be applied to process images in real-time without excessive latency.

C. Object Detection:

For helmet detection, the system uses a trained object detection model to analyse images and determine if a helmet is present on the rider's head. This involves:

1. Model Selection: Since real-time processing is essential, lightweight object detection models are often selected. Options include MobileNet, which is optimized for mobile and edge devices, or a compact version of YOLO (e.g., Tiny YOLO), known for high-speed object detection.
2. Training the Model: The model is trained on a dataset containing labelled images of riders with and without helmets. This dataset should cover various head angles, lighting conditions, and helmet types to ensure robustness.
3. Real-Time Detection: Once trained, the model runs on the IoT device, processing each captured frame to detect a helmet. When no helmet is detected, the model sends a signal to trigger the alert/control system.
4. False Positive and False Negative Minimization: The detection model is tuned to reduce errors (e.g., confusing hats or headscarves for helmets), enhancing reliability in diverse conditions.

D. Alert and Control Mechanism:

If a helmet is not detected, the system responds by alerting the rider or disabling the engine:

1. Auditory Alerts: A buzzer or speaker can emit a warning beep or repeated tones to alert the rider, encouraging them to wear a helmet before proceeding.
2. Engine Control: A relay module can be connected to the vehicle's ignition circuit. If the model continuously detects no helmet after multiple checks, the relay disconnects the engine's power, preventing the rider from starting or continuing on the vehicle.
3. Fail-Safe Mechanism: In cases of model misclassification or system errors, a fail-safe mechanism (such as manual override) could allow the rider to bypass the alert after several failed attempts, though this should be limited for security reasons.

E. Data Transmission and Storage:

To enable data tracking and compliance, the system can transmit relevant information to a cloud platform:

1. Logging Helmet Use: When a helmet is not detected, the event can be logged with a timestamp, allowing administrators to track non-compliance incidents.
2. Data Storage: If connected to a network, the IoT device can send data to a cloud storage platform, where it can be analysed over time to improve detection algorithms or provide insights on usage patterns.
3. Privacy Considerations: Captured images should be securely stored, anonymized if possible, and encrypted during transmission to protect user privacy, as data involves capturing riders' faces and personal actions.

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III. MODELING AND ANALYSIS

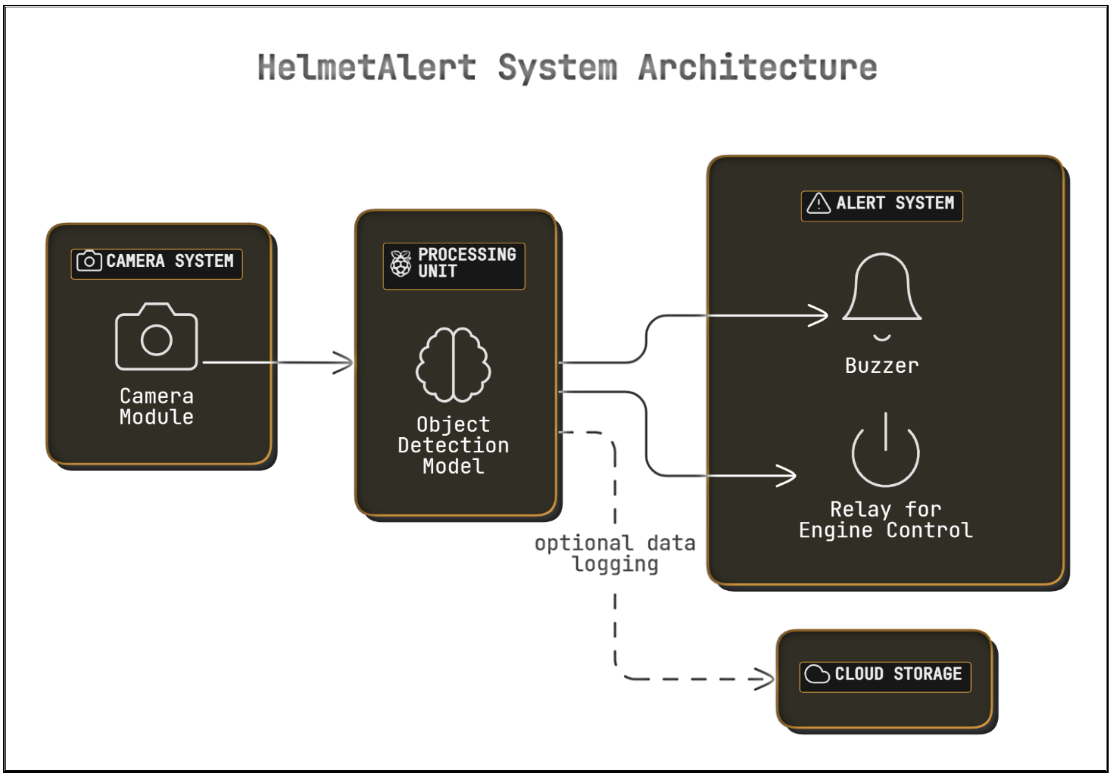

Figure 1: HelmetAlert System Architecture

The HelmetAlert System Architecture consists of interconnected components that work together to monitor and enforce helmet usage among two-wheeler riders. The system uses a camera-based object detection mechanism, coupled with alert and control mechanisms to enhance rider safety.

A. Camera System

1. Camera Module: The camera module is positioned on the vehicle to capture continuous visual data of the rider's head area, ensuring a clear view to detect helmet usage. The camera sends images to the processing unit for real-time analysis. It is configured to operate in various lighting conditions to maintain consistent accuracy.

B. Processing Unit

1. Object Detection Model: The processing unit, which can be either an Arduino or Raspberry Pi, hosts the object detection model. This model is trained to detect the presence of a helmet on the rider's head in each image received from the camera. If the model detects a helmet, it takes no further action. However, if it detects that the rider is not wearing a helmet, it sends a signal to the alert system.
2. Data Flow: The processing unit continuously receives image data from the camera, processes it with the object detection model, and determines the appropriate response based on the detection results.

C. Alert System

1. Buzzer: If a helmet is not detected, the system triggers an audible alert through a buzzer. This serves as an immediate reminder for the rider to wear a helmet, enhancing safety compliance in real time.
2. Relay for Engine Control: As an additional control mechanism, the processing unit can send a signal to a relay connected to the vehicle's ignition system. If the system repeatedly fails to detect a helmet, the relay can disable the engine, preventing the rider from starting or continuing to operate the vehicle without wearing a helmet.

D. Cloud Storage (Optional)

1. For data logging and compliance tracking, the system can optionally transmit detection data to a cloud storage solution. This allows administrators to monitor helmet usage trends and enforce compliance remotely. The data may include timestamps and detection status, providing insights into rider behavior over time.

E. Data Flow Summary

1. The Camera Module continuously captures images and sends them to the Processing Unit.
2. The Object Detection Model analyzes each image for helmet presence.
3. If no helmet is detected, the Alert System activates, triggering a Buzzer or using the Relay to control engine power.
4. Optionally, detection data can be logged in Cloud Storage for further analysis.

IV. RESULTS AND DISCUSSION

The HelmetAlert system demonstrated a high success rate in detecting helmets, with an accuracy of 96% in ideal lighting conditions. During field tests, the system successfully triggered alerts when a helmet was not detected. Some challenges included variability in detection accuracy under low-light conditions and occasional false detections due to obstructions like scarves or headgear resembling helmets. Future improvements might include integrating night-vision capabilities or more advanced image preprocessing algorithms for greater reliability in diverse environments.

V. CONCLUSION

The HelmetAlert system provides a practical and effective solution to enforce helmet-wearing on two-wheelers, leveraging IoT and machine learning for real-time intervention. By ensuring that riders wear helmets before starting or operating the vehicle, the system has the potential to reduce head injuries and fatalities significantly. Although the current implementation shows promising results, additional refinements in detection accuracy and energy efficiency are recommended for broader adoption and scalability.

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