RFID Enabled Embedded System for Autonomous Speed Control and Collision Avoidance

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ABSTRACT

Road traffic accidents continue to pose a significant threat to public safety worldwide, with speeding and human oversight being major contributing factors. To address this challenge, the proposed project introduces an intelligent speed control system that minimizes collision risks using embedded systems integrated with Radio-Frequency Identification (RFID) technology.

The system is designed to dynamically detect nearby vehicles or robotic entities using passive RFID tags. A microcontroller interprets these signals and adjusts the vehicle's or robot's speed accordingly. This mechanism ensures a reduction in collisions, particularly in environments like industrial zones or mining operations where sharp turns and blind spots are common.

This model is especially suitable for industrial robots or autonomous systems that operate continuously. The integration allows for smooth navigation around corners and gradients, thereby increasing safety and efficiency. The proposed method improves detection precision, shortens response time, and adapts effectively to different operating conditions.

Keywords: Anti-collision, RFID, Embedded System, Speed Control, Autonomous Navigation, Proximity Detection, Industrial Safety, Microcontroller.

INTRODUCTION

In recent years, road safety has emerged as a critical concern due to the growing number of accidents caused by high-speed driving and human negligence. Conventional safety systems often rely on visual sensors or manual intervention, which may not be sufficient in dynamic or hazardous environments. To address this issue, there is a pressing need for automated systems that can detect potential collisions and take preventive actions in real time.[1]

This project introduces an embedded system-based solution that employs Radio-Frequency Identification (RFID) technology to create an intelligent anti-collision speed control mechanism. The system is designed to detect nearby objects or vehicles using passive RFID tags and automatically regulate the speed of the vehicle or robotic unit.[2] This approach enhances safety by reducing the likelihood of accidents, especially in environments such as industrial areas or mining fields where visibility is low and terrain is complex. By integrating components such as a microcontroller, RFID reader, speed and ultrasonic sensors, and control circuits, the system ensures effective detection and timely response. Unlike traditional methods, this setup does not rely solely on human input, thereby increasing reliability and efficiency. The project demonstrates the potential of embedded systems in developing smart transportation and industrial safety solutions.[3]

LITERATURE REVIEW

The development of intelligent speed control and collision avoidance systems has gained momentum due to the increasing number of accidents caused by over-speeding and inadequate situational awareness. Several studies have explored the use of advanced sensing and communication technologies to tackle this issue. Traditional vehicle safety systems often rely on camera-based or radar-based sensors to detect nearby obstacles.[4] These systems, while effective in certain environments, suffer from limitations such as line-of-sight dependency, high cost, and reduced performance in adverse weather conditions. Moreover, most of these systems only provide alerts to the driver and do not actively intervene to control vehicle speed, which limits their effectiveness in preventing real-time collisions.[5]

Recent advancements in embedded systems and wireless communication have introduced the possibility of integrating technologies like RFID (Radio-Frequency Identification) for proximity detection. RFID offers a low-cost, efficient alternative that does not rely on visual input and functions reliably in environments where camera or radar may fail. For example, passive RFID tags can be used in vehicles or industrial robots to signal their presence to other systems equipped with RFID readers. This allows the embedded system to calculate proximity and initiate speed adjustments automatically.[6]

In the industrial and mining sectors, studies have demonstrated that RFID-based systems can significantly improve operational safety by enabling robots and vehicles to detect nearby objects and respond accordingly. This has been especially useful in navigating sharp turns**,** steep gradients, and low-visibility areas, where traditional systems are less effective.

Additionally, the combination of microcontrollers, speed sensors, ultrasonic sensors, and actuators in embedded platforms has enhanced the ability of safety systems to respond dynamically. Research also suggests that systems using Arduino platforms programmed in Embedded C offer flexibility for rapid prototyping and real-time execution, making them ideal for academic and developmental use cases. Despite ongoing improvements, many existing systems still lack seamless integration of detection and control functions. The proposed project addresses this gap by combining RFID technology with embedded control logic to create a fully autonomous anti-collision speed control system. This integrated approach not only ensures real-time obstacle detection but also introduces automated speed regulation, thereby contributing to safer navigation in both vehicular and robotic applications.[7]

PROPOSED METHODOLOGY

The core objective of this project is to design a smart anti-collision system that automatically regulates vehicle or robotic movement based on proximity detection using RFID technology integrated with embedded hardware.[8]

The system functions by detecting nearby objects or vehicles using passive RFID tags. Each unit is equipped with an RFID reader connected to a microcontroller, which interprets the signal data. Based on the received inputs, the system takes preventive actions, such as slowing down or stopping the motor, to avoid collisions. This automated approach eliminates the need for human intervention and enhances safety in critical environments like mines, industries, and robotics operations.[9]

System Architecture

The system architecture of the anti-collision speed control system is designed using a modular approach, combining embedded hardware and software components to detect potential obstacles and regulate speed in real-time. This architecture ensures safe and efficient navigation in industrial or vehicular environments.[13] Block Diagram of Anti-Collision Speed Control System Based on Embedded System Using RFID is shown in Fig 1.

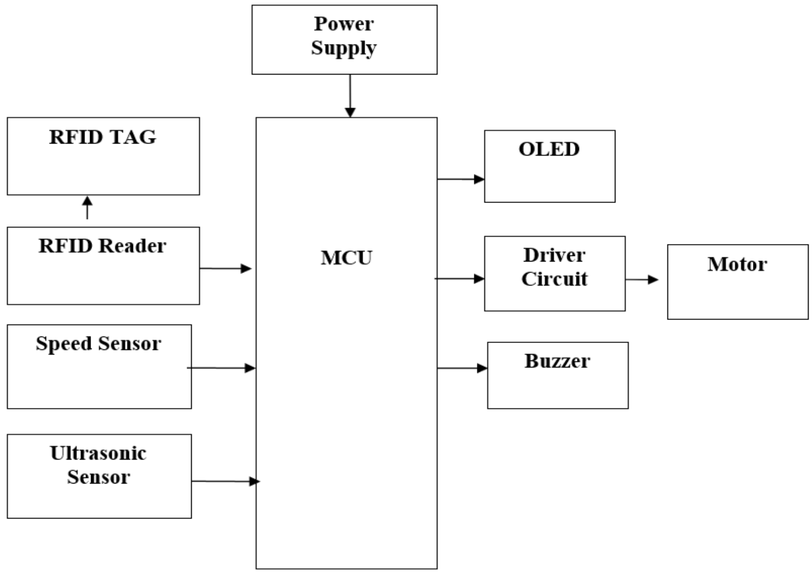

Fig 1: Block Diagram of Anti-Collision Speed Control System Based on Embedded System Using RFID

The main modules of the system are Transmitter module, Receiver module and RF module.

Transmitter module: The transmitter module plays a key role in initiating communication within the anti-collision system. It is responsible for continuously broadcasting identification signals that can be detected by nearby receivers. In this project, passive RFID tags act as the primary transmission units, allowing surrounding vehicles or robots to detect their presence and respond accordingly.

Receiver module: The receiver module is the heart of the anti-collision speed control system. It is installed on the vehicle or robotic unit and is responsible for detecting nearby RFID tags, interpreting data, and initiating necessary actions to maintain a safe distance from obstacles or other moving units.

RF module: The RF Module serves as a critical communication bridge between the RFID tags and the microcontroller, enabling the system to detect and process signals for dynamic speed control. In this project, the RF module consists of an RFID reader and antennas that interact with passive RFID tags placed on vehicles, robots, or other objects.[12]

Transmitter

The transmitter module plays a key role in initiating communication within the anti-collision system. It is responsible for continuously broadcasting identification signals that can be detected by nearby receivers. In this project, passive RFID tags act as the primary transmission units, allowing surrounding vehicles or robots to detect their presence and respond accordingly.

Each RFID tag is encoded with a unique identifier and does not require an internal power supply, making it highly energy-efficient and suitable for continuous use. These tags are strategically mounted on vehicles, robots, or fixed structures within operational areas such as mining zones or industrial paths.[10]

When a vehicle equipped with an RFID reader comes within range, the electromagnetic field generated by the reader activates the passive tag. The tag then transmits its stored data, which is interpreted by the reader and forwarded to the microcontroller for further processing.

This module does not actively process information but serves as a passive identifier, enabling the receiving system to recognize nearby entities and make informed speed control decisions. Its simplicity and reliability make it a practical solution for proximity detection in dynamic environments.

Receiver

The receiver module is the heart of the anti-collision speed control system. It is installed on the vehicle or robotic unit and is responsible for detecting nearby RFID tags, interpreting data, and initiating necessary actions to maintain a safe distance from obstacles or other moving units.

At the core of the receiver module is an RFID reader, which continuously scans its surroundings for any RFID signals. When it detects a tag within its operational range, it reads the identification data and sends it to the microcontroller for processing. The microcontroller analyses the information to determine whether the detected object poses a risk of collision.

If the proximity between the objects falls below the safety threshold, the microcontroller activates a series of responses.

The proposed system is designed to prevent vehicle collisions by automatically detecting nearby obstacles or vehicles and controlling the vehicle's speed using RFID and sensor-based technologies integrated into an embedded system.

SIMULATION AND RESULTS

To evaluate the effectiveness of the proposed anti-collision speed control system, simulations were conducted using the Arduino IDE. The logic was written in Embedded C and tested on an Arduino-compatible microcontroller connected to relevant hardware components such as RFID readers, ultrasonic sensors, and motor drivers.

Fig 2: Simulation and results of Anti-Collision Speed Control System Based on Embedded System Using RFID

The simulation confirms that the proposed system successfully automates collision avoidance by dynamically adjusting the speed based on real-time environmental input. The integration of RFID with embedded system demonstrates an effective alternative to camera and radar-based solutions, particularly in industrial environments like mining where visibility may be limited.

CONCLUSION

The development of an anti-collision speed control system using embedded technology and RFID marks a significant step toward enhancing road and industrial safety. Through the integration of RFID readers, ultrasonic sensors, and real-time speed control mechanisms, the system effectively detects nearby objects and adjusts vehicle speed to prevent accidents.

This project demonstrates how embedded systems can be employed to automate safety measures, especially in environments like mining sites or warehouses where manual control may be unreliable or delayed. The use of RFID allows for quick identification of other moving units, while the ultrasonic sensor adds an additional layer of safety by detecting stationary obstacles.[14]

By combining affordable hardware components and efficient software logic, the system operates with reliability and accuracy, ensuring rapid response to potential threats. The results from simulation and practical testing validate the system's ability to function under real-time constraints and varying environmental conditions.

In conclusion, this project provides a practical and scalable solution for automated collision avoidance. With further enhancements, such systems can be integrated into smart transportation networks and industrial automation frameworks, contributing to the broader goal of accident-free operation.[15]

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