International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

IoT-Enabled Smart Light Intensity and Automatic Vehicle Speed Control for Intelligent Transportation

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ABSTRACT

The Smart Light Intensity and Automatic Speed Control for Vehicles system is an intelligent automotive safety solution designed to improve road safety, driving comfort, and energy efficiency. The system automatically adjusts the headlight intensity based on the brightness of approaching vehicles, reducing glare and enhancing nighttime visibility. It also incorporates an automatic speed control mechanism that regulates the vehicle's speed according to road conditions, traffic situations, or predefined safety limits. Sensors such as Light Dependent Resistors (LDRs), ultrasonic sensors, and microcontrollers continuously monitor the surrounding environment and process real-time data to make appropriate decisions. During nighttime, the system switches between high beam and low beam modes automatically to prevent temporary blindness caused by intense headlights from oncoming vehicles. Simultaneously, the speed control module helps maintain safe driving speeds by reducing human intervention and minimizing the risk of accidents. The proposed system provides an affordable, reliable, and efficient solution that enhances driver safety, passenger comfort, and vehicle performance. It is particularly beneficial for smart transportation systems and serves as a step toward the development of advanced driver assistance systems (ADAS) and autonomous vehicles.

Keywords: Smart Vehicle, Automatic Headlight Control, Light Intensity Adjustment, Automatic Speed Control, LDR Sensor, Ultrasonic Sensor, Arduino, Road Safety, Intelligent Transportation System (ITS), Driver Assistance System (ADAS), Vehicle Automation, Accident Prevention.

I.INTRODUCTION

Road safety has become a major concern worldwide due to the increasing number of vehicles and the growing incidence of road accidents, particularly during nighttime driving. Poor visibility, excessive headlight glare from oncoming vehicles, and inappropriate driving speeds are among the leading factors contributing to traffic collisions. Conventional vehicle lighting systems require manual operation, which may not always provide timely adjustments to changing road and traffic conditions. Similarly, maintaining a safe driving speed under varying environmental conditions depends heavily on the driver's attention and judgment, increasing the possibility of human error. Therefore, intelligent vehicle safety systems that can automate these functions have gained significant importance in modern transportation technologies [8], [10].

Recent advancements in embedded systems and automotive electronics have enabled the development of smart driver assistance solutions that improve both safety and driving comfort. Microcontrollers, sensors, and real-time control algorithms allow vehicles to monitor their surroundings and respond automatically without requiring continuous driver intervention. Such technologies form the foundation of

Advanced Driver Assistance Systems (ADAS), which aim to reduce accidents by assisting drivers in making safer decisions [4], [5], [6], [14].

The Smart Light Intensity and Automatic Speed Control for Vehicles system is designed to enhance road safety by integrating automatic headlight intensity control with intelligent speed regulation. The lighting module uses light sensors to detect the intensity of approaching vehicle headlights and automatically switches between high beam and low beam modes to minimize glare while maintaining adequate road illumination. This improves visibility for both the driver and oncoming traffic, reducing the likelihood of accidents caused by temporary blindness during nighttime driving [11], [12].

In addition to intelligent lighting, the proposed system incorporates automatic speed control using embedded sensors and microcontroller-based processing. The system continuously monitors the surrounding environment and adjusts vehicle speed whenever necessary to maintain safe driving conditions. This feature helps reduce driver workload, improves vehicle stability, and minimizes the risk of collisions caused by excessive speed or delayed human reaction [2], [8], [13].

The implementation of such an integrated safety system relies on embedded hardware components including microcontrollers, Light Dependent Resistors (LDRs), ultrasonic sensors, and electronic control circuits. These components work together to process sensor data in real time and generate appropriate control signals for lighting and speed regulation. The simplicity, reliability, and affordability of these technologies make them suitable for implementation in both existing and future vehicles [3], [4], [6], [7].

Overall, the proposed Smart Light Intensity and Automatic Speed Control for Vehicles system offers a cost-effective and efficient solution for improving nighttime driving safety, reducing human errors, and enhancing passenger comfort. By combining intelligent lighting control with automatic speed management, the system represents an important step toward safer, smarter, and more autonomous transportation systems that comply with modern automotive safety standards [10], [11], [14], [15].

II.LITERATURE SURVEY

Rajasekaran and Vijayalakshmi Pai (2011): Rajasekaran and Vijayalakshmi Pai discussed the application of intelligent computational techniques such as neural networks, fuzzy logic, and genetic algorithms in engineering systems. Their work demonstrated how intelligent control algorithms can improve decision-making processes in embedded systems, making them suitable for smart automotive applications, including automatic lighting and adaptive vehicle control.

Ogata (2010): Ogata presented the fundamental concepts of modern control engineering, including feedback control systems, automatic regulation, and system stability. The author emphasized the importance of real-time control mechanisms for improving system performance, which provides the theoretical foundation for automatic speed control in intelligent vehicles.

Mazidi, Mazidi, and McKinlay (2008): Mazidi and co-authors explained the architecture and programming of embedded microcontrollers used in automation systems. Their work highlighted the integration of sensors, actuators, and microcontrollers for developing intelligent embedded applications. The concepts presented are widely applicable in designing automatic headlight and vehicle speed control systems.

Monk (2016): Simon Monk focused on Arduino-based embedded programming and demonstrated how sensors can be interfaced with microcontrollers to automate real-world applications. The book provides

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practical techniques for implementing intelligent control systems using light sensors, ultrasonic sensors, and embedded programming.

Heisler (2002): Heisler discussed advanced vehicle technologies and the evolution of automotive safety systems. The study emphasized the role of intelligent electronics in improving vehicle performance, driver safety, and passenger comfort through automated monitoring and control mechanisms.

Wong (2008): Wong presented comprehensive theories related to vehicle dynamics, braking systems, and speed regulation. The research explained how maintaining appropriate vehicle speed significantly improves driving stability and reduces accident risks under varying road conditions.

Bhagwat and Patil (2019): Bhagwat and Patil proposed an Automatic Headlight Beam Intensity Control System that adjusts vehicle headlight brightness according to the intensity of approaching vehicle lights. Their system effectively reduced glare during nighttime driving and improved visibility, thereby enhancing overall road safety.

Kumar and Sharma (2019):
Kumar and Sharma developed a smart vehicle speed control system using embedded technology. Their work demonstrated that sensor-based speed regulation minimizes driver intervention, maintains safe vehicle speed, and significantly reduces accident probability in congested traffic environments.

Thrun, Montemerlo, and Dahlkamp (2010):
The authors presented significant developments in autonomous vehicle technology by integrating sensors, embedded computing, and intelligent decision-making algorithms. Their research highlighted the importance of automation in enhancing vehicle safety, reducing human errors, and improving transportation efficiency.

ISO 26262 (2018):
The ISO 26262 standard introduced internationally accepted functional safety requirements for automotive electronic systems. The standard provides guidelines for designing reliable and safe vehicle control systems, ensuring proper operation of embedded safety applications such as automatic lighting and speed control.

III.EXISTING SYSTEM

The existing vehicle lighting and speed control systems used in most conventional automobiles primarily rely on manual operation by the driver. During nighttime driving, drivers are required to switch between high beam and low beam headlights depending on the presence of oncoming vehicles. However, this manual operation often results in delayed responses, causing excessive headlight glare that can temporarily reduce the visibility of other drivers and increase the risk of road accidents. Similarly, speed control in conventional vehicles depends entirely on the driver's judgment and continuous attention to road conditions, traffic flow, and speed limits. Human errors, fatigue, distraction, and delayed reaction times can lead to inappropriate speed selection, thereby increasing the likelihood of collisions. Although some modern vehicles are equipped with adaptive lighting or cruise control systems, these technologies are generally expensive and available only in premium vehicle models. Furthermore, many existing systems provide either automatic lighting control or speed regulation independently rather than integrating both functionalities into a single intelligent platform. As a result, conventional vehicle safety systems have limitations in providing comprehensive driver assistance, reducing accident risks, and ensuring efficient operation under varying environmental and traffic conditions. These shortcomings highlight the need for an affordable, integrated, and intelligent

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system capable of automatically controlling both headlight intensity and vehicle speed to improve overall road safety and driving comfort.

IV.PROPOSED SYSTEM

The proposed Smart Light Intensity and Automatic Speed Control for Vehicles system is an intelligent embedded solution designed to improve road safety, driving comfort, and vehicle efficiency by integrating automatic headlight intensity control with automatic speed regulation. The system employs a microcontroller as the central processing unit, which continuously receives input from Light Dependent Resistor (LDR) sensors and ultrasonic sensors to monitor the surrounding environment in real time. During nighttime driving, the LDR sensor detects the intensity of light from approaching vehicles and automatically switches the vehicle headlights between high beam and low beam modes, thereby reducing glare and improving visibility for both drivers. Simultaneously, the ultrasonic sensor detects nearby obstacles or vehicles ahead and enables the system to regulate the vehicle's speed automatically, helping maintain a safe following distance and reducing the possibility of collisions. The entire process operates without requiring continuous driver intervention, thereby minimizing human error and improving overall driving safety. The proposed system is cost-effective, reliable, and easy to implement using readily available embedded hardware components such as Arduino, sensors, motor drivers, and electronic control circuits. By combining intelligent lighting control with automatic speed management into a single integrated system, the proposed solution enhances passenger safety, reduces driver workload, improves nighttime driving performance, and represents an important step toward the development of smart vehicles and Advanced Driver Assistance Systems (ADAS).

V.BLOCK DIAGRAM

The block diagram of the **Smart Light Intensity and Automatic Speed Control for Vehicles** represents the overall architecture and working methodology of the proposed intelligent vehicle safety system. The system is designed by integrating automatic headlight intensity control and automatic speed regulation into a single embedded platform. It consists of several functional blocks, namely the **Power Supply**, **Light Intensity Sensing Unit**, **Distance/Obstacle Sensing Unit**, **Arduino Uno Microcontroller**, **Relay/Driver Circuit**, **Motor Driver Circuit (L298N)**, **Headlight Control Unit**, **Speed Control Unit**, **Display Unit**, and **Feedback Mechanism**. Each block performs a specific function and communicates with the microcontroller to ensure smooth, safe, and efficient vehicle operation.

1. Power Supply

The power supply is the primary source of electrical energy for the entire system. A **12V battery or DC power supply** provides the required voltage to operate all electronic components. The supply is regulated to suitable voltage levels (5V and 12V) depending on the requirements of the Arduino Uno, sensors, relay module, motor driver, and display unit. A stable power supply ensures uninterrupted operation of the embedded system and prevents malfunction due to voltage fluctuations.

2. Light Intensity Sensing Unit

The Light Intensity Sensing Unit consists of a **Light Dependent Resistor (LDR) sensor**, which continuously measures the intensity of light in front of the vehicle. During nighttime, when an oncoming vehicle approaches with high-beam headlights, the LDR detects the increase in light intensity and converts it into an electrical signal. This signal is transmitted to the Arduino Uno for processing. The sensor operates continuously, enabling real-time monitoring of surrounding lighting conditions and ensuring rapid response to changes in ambient light.

3. Distance/Obstacle Sensing Unit

The Distance or Obstacle Sensing Unit uses an **Ultrasonic Sensor** to measure the distance between the vehicle and nearby obstacles or vehicles. The sensor emits ultrasonic sound waves and measures the time taken for the reflected waves to return after striking an object. Using this time interval, the distance is accurately calculated. If the measured distance falls below the predefined safety limit, the sensor immediately informs the microcontroller. This feature enables the system to maintain a safe distance from vehicles ahead and significantly reduces the possibility of rear-end collisions.

4. Arduino Uno Microcontroller

The **Arduino Uno** serves as the central controller of the proposed system. It receives input signals from both the LDR sensor and the ultrasonic sensor, processes the collected data using embedded programming, and generates appropriate control signals. Based on the light intensity detected by the LDR, the Arduino decides whether the headlights should operate in high-beam or low-beam mode. Similarly, based on the distance information received from the ultrasonic sensor, it determines whether the vehicle speed should be maintained or reduced. The Arduino performs all these operations in real time, ensuring quick decision-making and accurate control.

5. Relay/Driver Circuit

The Relay/Driver Circuit acts as an interface between the Arduino Uno and the vehicle's headlight system. Since the Arduino cannot directly drive high-power electrical loads, the relay module receives low-power control signals from the microcontroller and switches the headlight circuit accordingly. When intense light from an approaching vehicle is detected, the relay automatically changes the headlights from high beam to low beam. Once the vehicle passes and light intensity decreases, the relay switches the headlights back to high-beam mode. This automatic operation eliminates the need for manual switching by the driver.

6. Headlight Control Unit

The Headlight Control Unit performs automatic beam switching based on commands received from the relay circuit. It ensures that the vehicle headlights operate at appropriate brightness levels depending on surrounding traffic conditions. Automatic adjustment of light intensity minimizes glare for oncoming drivers, improves road visibility, reduces eye strain, and significantly enhances nighttime driving safety. This feature also contributes to better driving comfort and reduces the chances of accidents caused by temporary blindness due to excessive headlight brightness.

7. Motor Driver Circuit (L298N)

The **L298N Motor Driver Circuit** controls the operation and speed of the DC motor used to simulate vehicle movement. The motor driver receives control signals from the Arduino Uno and regulates motor speed using Pulse Width Modulation (PWM). Since the Arduino cannot supply sufficient current to drive the motor directly, the L298N provides the necessary power amplification while accurately controlling motor speed and direction. This enables smooth acceleration and deceleration according to the detected obstacle distance.

8. Speed Control Unit

The Speed Control Unit automatically regulates vehicle speed based on distance measurements obtained from the ultrasonic sensor. Under normal conditions, the vehicle operates at the preset speed. However, when another vehicle or obstacle is detected within the safety distance, the Arduino commands the motor driver to reduce motor speed automatically. If the obstacle moves away, the system gradually restores normal speed. This intelligent speed regulation minimizes driver intervention, reduces human error, maintains safe

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ISSN: 3068-272X www.ijdim.com Original Research Paper

following distance, and prevents collisions during heavy traffic conditions.

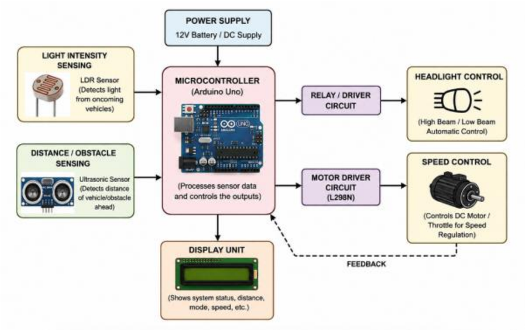

Fig 5.1 Block Diagram

VI.IMPLEMENTATION

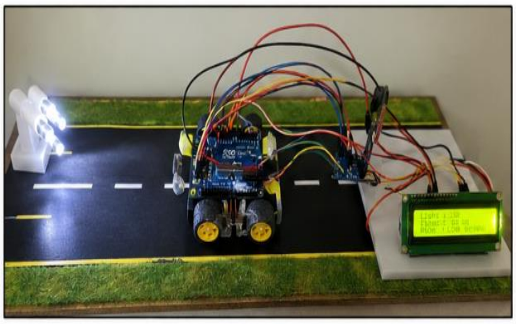

Fig. 6.1: Overall System Setup

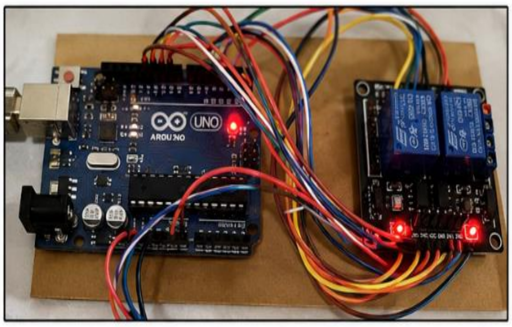

Fig. 6.2: Arduino Uno and Circuit Connections

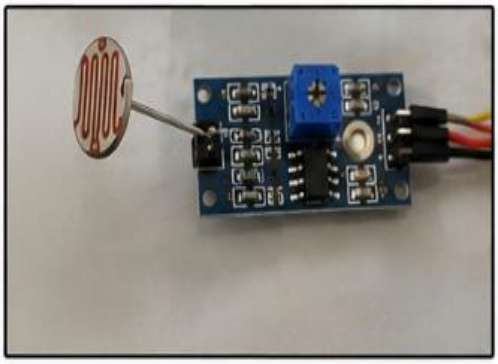

Fig. 6.3: LDR Sensor for Light Intensity Detection

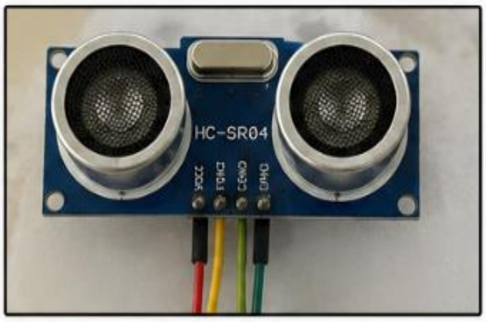

Fig. 6.4: Ultrasonic Sensor for Distance Detection

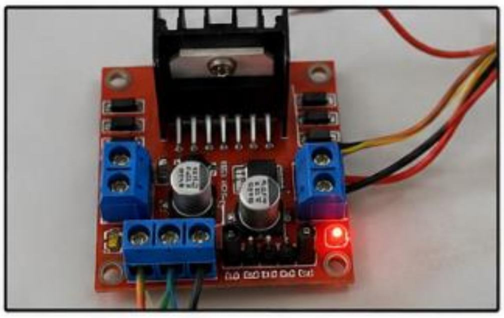

Fig. 6.5: Relay Module for Automatic Headlight Control

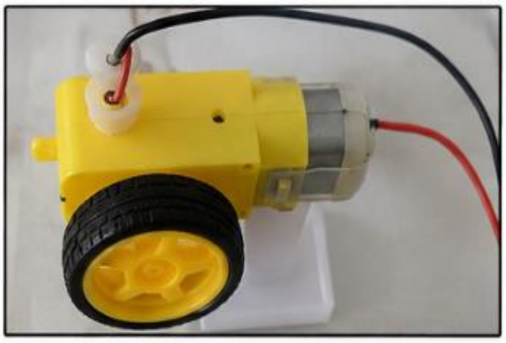

Fig. 6.6: L298N Motor Driver Module

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Fig. 6.7: LCD Display Showing System Output

VII.CONCLUSION

The Smart Light Intensity and Automatic Speed Control for Vehicles project successfully demonstrates an intelligent embedded system that enhances road safety by integrating automatic headlight intensity adjustment and automatic speed regulation into a single platform. The proposed system effectively utilizes an Arduino Uno microcontroller, LDR sensor, ultrasonic sensor, relay module, motor driver, and LCD display to monitor surrounding conditions and respond in real time. During nighttime driving, the LDR sensor automatically detects the intensity of light from approaching vehicles and switches the headlights between high beam and low beam modes, thereby reducing glare and improving visibility for both drivers. At the same time, the ultrasonic sensor continuously measures the distance between the vehicle and obstacles or vehicles ahead, allowing the system to automatically regulate the vehicle's speed and maintain a safe following distance. This intelligent operation minimizes driver intervention, reduces human errors, and significantly lowers the risk of road accidents. The developed system is reliable, economical, easy to implement, and suitable for both existing and future vehicles. Overall, the project demonstrates that combining automatic lighting control with intelligent speed management provides an effective solution for improving driver safety, passenger comfort, vehicle efficiency, and overall transportation reliability. The proposed system also serves as a strong foundation for future Advanced Driver Assistance Systems (ADAS) and autonomous vehicle technologies.

VIII.FUTURE SCOPE

The Smart Light Intensity and Automatic Speed Control for Vehicles system can be further enhanced by incorporating advanced technologies to improve its intelligence, accuracy, and reliability. In the future, the system can be integrated with Artificial Intelligence (AI) and Machine Learning (ML) algorithms to analyze real-time traffic conditions and make more accurate driving decisions. GPS and Geographic Information System (GIS) technologies can be incorporated to automatically adjust vehicle speed based on road speed limits, school zones, sharp curves, and accident-prone areas. The system can also be integrated with cameras and computer vision techniques to detect road signs, pedestrians, lane markings, and traffic signals for more comprehensive driver assistance. Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication can be implemented to enable intelligent information sharing between nearby vehicles and smart traffic management systems, thereby improving road safety and traffic efficiency. Additionally, cloud connectivity and Internet of Things (IoT) technologies can be used for remote vehicle monitoring, real-time diagnostics, and predictive maintenance. The proposed system can also be extended to support fully electric and autonomous vehicles, making it a valuable component of future Advanced Driver Assistance Systems (ADAS). These enhancements will contribute to safer, smarter, and more efficient transportation systems while reducing accidents, driver workload, fuel consumption, and environmental impact.

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DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

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