

Automatic Headlight Dimmer System with Seat adjustment

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Abstract. With regard to night-time driving, it has been identified that headlamp glare and beam alignment are of prime importance for two-wheeler riders as well as vehicle drivers with varying seating positions. An adaptive intelligent system for an automatic headlamp dip and dim system with a servo motor-actuating leveling mechanism has been presented for improving driver visibility and reducing glare due to varying vehicle driving conditions. Light and infrared sensors have been utilized with an Arduino system to recognize ambient light as well as oncoming vehicles, followed by an I2C LCD display that acts as a continuous feedback system for the entire process, thus providing an intelligent system for a cost-effective solution with an increased level of comfort for vehicle riders.

Keywords: Automatic Headlamp Dip and Dim, Adaptive Headlight control, Arduino uno, Automotive safety systems, Night time Driving safety.

1 Introduction

Night time road safety is a crucial issue in the modern transportation sector, especially in narrow roads, highways, and hilly areas where the level of visibility is inherently compromised, irrespective of the level of use of headlights. One of the biggest challenges facing drivers and two-wheeler riders, especially when traveling at night, is the glare effect from headlamps used in other approaching vehicles, leading to temporary discomfort, loss of contrast vision, and increased reaction time. The use of headlamps in an inappropriate configuration accelerates the risk level in compromised visibility conditions. A conventional headlight system mainly uses either manual dip and dim or a fixed position in a beam, which is unable to adaptively respond to dynamic driving environments, vehicle load variables, and rider/driver ergonomics. In these contexts, recently introduced systems for automatic headlamp dimming also tended to compromise forward visibility, particularly in the case of short riders or when drivers assume lower seating positions. The inability to adapt beam leveling with ergonomic consideration restricts the functionality of conventional systems to ensure safety for drivers of all kinds.

In overcoming the shortcomings of the existing systems, this paper proposes the design and development of an adaptive automatic dip and dim for headlamps that integrates a servo motor-based leveling mechanism.

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The proposed system will make use of real-time ambient light detection and oncoming object detection technology to comprehend the intensity requirements of headlamps by adapting to the comfort position of the vehicle occupant. Through the effective integration of microcontroller-based technology and the ergonomic requirements of vehicle occupants, the proposed system will improve the visibility of the road environment at night. The proposed system will also overcome the effects of headlight glare for oncoming traffic.

2 Related work

This has become the recent areas of research in automotive lighting systems: to improve night-time driving safety, reduce glare from oncoming vehicles without conceding too much road illumination. Various authors have proposed an automatic headlamp control system that overcomes some limitations of manual dip and dim operation that oftentimes depends on driver reaction time and alertness. These systems are aimed at improving visibility, reducing eye strain, and minimizing accident risks in night driving conditions [1]. Zhou et al. in [1] introduced an automatic headlamp leveling system using a suspension height measurement approach to adapt to the impact of load on the vehicle as well as the angle of the road. This approach ensures beam adjustment by dynamically adjusting the angle of the headlamp, but the primary consideration is based on vehicle dynamics rather than factors unique to the rider, such as rider position. Guan et al. in [4] also introduced an optimized computation approach for headlamp leveling systems based on accuracy and stability in beam positioning. Vinothkumar et al. [2] proposed a smart headlight system that uses situation-aware sensing to automatically adapt the headlamp's behavior based on driving situations. Kavitha et al. [3] proposed a microcontroller-based adaptive headlight automation system, which was designed to enhance safety under advanced environmental conditions such as fog and rain. Their proposed works appear to be very effective for embedded control and sensor integration for the automatic headlight modulation functions; however, they mainly focus on beam control over driver comfort. Sripriya et al. [5] proposed an independent light sensing-based adaptive headlight system that provides better glare detection accuracy. Hedge et al. [6], on the other hand, developed adaptive headlight control using the Q-learning reinforcement algorithm. The controller can learn optimal beam adjustment policies over time using the chosen algorithm. However, these methods increase system complexity and cost and hence are not quite as feasible for low cost or two-wheeler applications. Zhang et al. also proposed an adaptive driving beam system along with an integrated automatic lamp control system. It is quite evident that these systems have greatly helped in improving the overall visibility on the roads. However, these systems require quite complex sensors or systems. It has been analyzed that considerable advancement has been made in the field of automatic headlamp dimming and leveling systems. Nevertheless, little emphasis has been placed on the incorporation of certain ergonomic changes, as in the proposed work, the level of the rider's seats might be adjusted in accordance with the short riders during the low beam headlights.

2.1 Problem Definition

Although there has been significant improvement in developing auto control systems for head lamps, safety during driving at nighttime is still a major problem due to glare and inappropriate beam positioning. Manual actions like dipping and dimming need driver response time; hence, there is unnecessary delay in actions like dimming and dipping. These actions lead to blindness. Although auto dim control is used to diminish glare, in practice, vision is obstructed or minimized, especially in low-beam operation for short riders. Another aspect that has not been considered in headlamp auto control is ergonomics.

2.2 Research Objectives

- The need to design an automatic headlamp dip and dim system that does not require driver intervention.
- For reduction of glare from approaching vehicle head lamps while driving at night.
- To incorporate a servo motor-based seat leveling system for better visibility of the rider's feet, especially for shorter riders.
- To improve comfort levels for riders and safety on the road through automation.
- A system that is efficient and affordable for practical usage.

3 Proposed System Architecture

Proposed system architecture is designed to improve night-time driving safety by simultaneously reducing glare from oncoming vehicles and enhancing road visibility for short riders during low-beam operation. Unlike conventional automatic headlamp dimming systems that focus only on the control of beam intensity, the proposed approach integrates automatic headlamp dip and dim control with a servo motor-based seat height adjustment mechanism, hence addressing both the issues of glare mitigation and rider ergonomics.

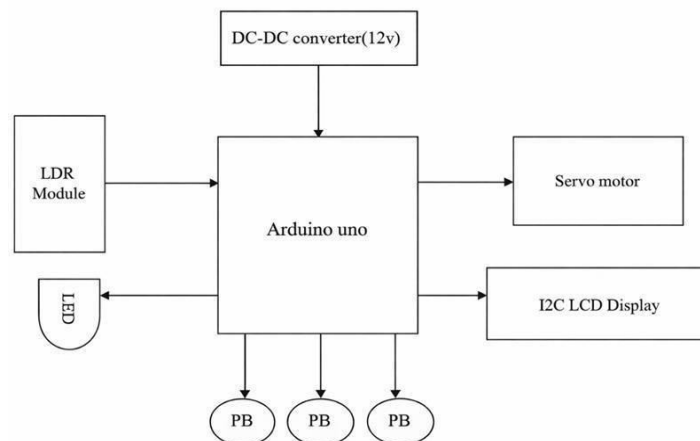


Fig.1 Block diagram of the proposed automatic headlamp dimming and seat adjustment system.

3.1 Power supply unit

Additionally, the power supply unit transforms the input voltage from the 12V DC source to a stable 5V using a DC-DC converter, enabling the microcontroller, sensors, servo motor, and display to be powered.

3.2 Sensing unit

The sensing unit uses a Light Dependent Resistor-LDR to monitor continuously ambient and oncoming vehicle headlight intensity and provides an analogue signal to the control unit for glare detection.

3.3 Control Unit

This sensor input and user command are dealt with by the implemented control unit, using an Arduino Uno microcontroller, in a way to compute continuously the proper headlamp mode and seat height adjustment.

3.4 Actuation unit

The actuation unit includes the headlamp module and a servo motor that assists in switching automatically between the high and low beam and also the height adjustments of the seats.

3.5 Display and user interface unit

An I2C-based LCD display provides real-time feedback on beam mode and seat level, while push buttons allow for selection of predefined seat height positions required.

4 System Implementation

The automatic headlamp dip and dim control system is implemented using an Arduino Uno as the central control unit to manage sensor inputs and control output devices. The system uses an LDR module to continuously monitor ambient light intensity and detect the presence of strong light from oncoming vehicles. Based on the sensor readings, the Arduino processes the data and automatically switches between high and low beam modes to reduce glare and improve night-time visibility.

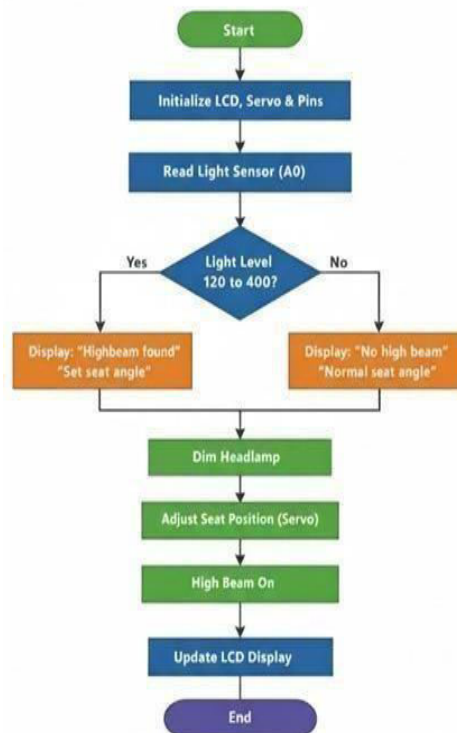


Fig.2 Flowchart.

A servo motor is integrated to provide automatic headlamp leveling by adjusting the beam angle according to vehicle load or seat position variations. This ensures proper illumination of the road while preventing discomfort to other drivers. Push buttons are included to allow manual control and mode selection whenever required, enhancing system flexibility and user interaction.

An I2C LCD display is incorporated to provide real-time feedback such as operating mode, light intensity status, and leveling position, which improves driver awareness and system transparency. The LED represents the headlamp output for prototype demonstration, indicating beam changes during operation.

Power is supplied through a 12V adapter, and a DC-DC converter regulates the voltage to suitable levels for the Arduino and other components, ensuring stable and safe operation. The integration of sensors, actuators, and display with a microcontroller results in a cost-effective, energy-efficient, and reliable system that minimizes manual intervention, reduces glare-related risks, and enhances overall driving safety.

Fig.2 explains the working process of the automatic headlamp dip and dim control system. The process begins with Start, where the system is powered on. The Arduino then initializes the LCD display, servo motor, and input/output pins so that all components are ready for operation. After initialization, the controller reads the light sensor (LDR) value from analog pin A0 to measure the surrounding light intensity and detect whether a strong beam from an oncoming vehicle is present.

Next, the system checks the light level range (120 to 400). If the detected value falls within this range, it indicates the presence of high-beam light from another vehicle. The LCD displays “High beam found” and the system sets the appropriate seat or headlamp angle. If the value is outside this range, the display shows “No high beam”, and the headlamp remains at the normal angle for clear visibility.

Once the condition is evaluated, the system automatically dims the headlamp to reduce glare for oncoming drivers. Simultaneously, the servo motor adjusts the headlamp position to ensure proper beam alignment. After the vehicle passes and the intense light is no longer detected, the system turns the high beam back on for improved road illumination.

Finally, the system updates the LCD display with the current status and continues monitoring the environment for further changes. This automated sequence minimizes manual effort, improves night-time driving safety, reduces glare, and ensures optimal lighting under varying road conditions.

The automatic headlamp dip and dim control system is centered around the Arduino Uno, which functions as the main processing unit. All sensors and output devices are connected to the Arduino to enable real-time monitoring and control. The LDR module is interfaced with the analog input pin (A0) to measure ambient light intensity. When the sensor detects a sudden increase in light—typically from an approaching vehicle—the Arduino interprets this as high-beam interference and immediately triggers the dimming mechanism. Predefined threshold values are programmed into the controller to ensure accurate detection and quick response.

The servo motor is connected to a PWM (Pulse Width Modulation) pin of the Arduino to enable precise angular movement. Based on the sensor data, the servo automatically adjusts the headlamp angle to maintain proper beam alignment. This feature is especially useful when there are variations in vehicle load or seat position, which can otherwise tilt the headlamp upward and cause glare. The system is programmed to smoothly rotate the servo between preset angles, ensuring stable and controlled adjustments without sudden movements.

An LED is used in the prototype to represent the vehicle headlamp, demonstrating the switching between high and low beam modes. Push buttons are incorporated to provide manual override and mode selection, allowing the driver to control the system when necessary. The I2C LCD display is interfaced using SDA and SCL pins, minimizing wiring complexity while providing real-time updates such as beam status, detected light level, and servo position. This improves system transparency and helps users easily understand the current operating condition.

Power management is achieved using a 12V adapter as the primary power source, while a DC-DC converter regulates the voltage to safer levels required by the Arduino and peripheral components.

This prevents damage from voltage fluctuations and ensures consistent performance. Proper grounding and secure connections are maintained throughout the circuit to enhance reliability and reduce electrical noise.

From a software perspective, the system is programmed using embedded C in the Arduino IDE. The algorithm continuously reads sensor values, compares them with threshold limits, and executes control actions accordingly. The loop-based program structure allows uninterrupted monitoring, ensuring that the headlamp responds instantly to environmental changes. Overall, the integration of sensing, control, display, and actuation creates a cost-effective, energy-efficient, and intelligent lighting solution that enhances driver comfort, reduces glare-related risks, and improves night-time driving safety.

The system is designed with a modular architecture, allowing individual components to be easily upgraded or replaced without affecting the overall functionality. For example, the LDR sensor can be substituted with more advanced light sensors or camera-based modules to further improve detection accuracy. This flexibility makes the system scalable and adaptable to future automotive technologies.

During implementation, special attention is given to response time and system reliability. The controller continuously samples sensor data at short intervals to ensure that the headlamp reacts instantly when an oncoming vehicle is detected. This rapid adjustment helps prevent temporary blindness caused by glare and supports safer decision-making for drivers. The use of efficient programming logic also reduces processing delay and optimizes overall system performance.

The prototype model is developed to demonstrate the practical feasibility of the system before real-world vehicle integration. Testing is performed under different lighting conditions to verify sensor sensitivity, servo movement accuracy, and display functionality. These tests help identify optimal threshold values and ensure that the system operates consistently in both low-light and high-glare situations.

Furthermore, the implementation prioritizes energy efficiency and low power consumption, making the system suitable for automotive environments where power management is important. The combination of simple hardware and intelligent control reduces unnecessary energy usage while maintaining high performance. Overall, this implementation provides a reliable, affordable, and user-friendly solution that supports modern vehicle safety requirements and contributes to the advancement of smart automotive lighting systems.

5 Results and Discussion

The project is demonstrated an integrated automotive safety and comfort system using an IR sensor for automatic light modulation and a Servo motor for precise seat leveling. Experimental testing confirmed that the system toggles headlight intensity upon detecting oncoming objects while maintaining three distinct, user-selectable seat positions via push-button inputs. All system statuses were accurately rendered on the I2C LCD, proving the reliability of the communication bus and the overall efficiency of the automated control logic.

Automatic Dimming (IR Sensing): The IR sensor successfully detected oncoming "traffic" (simulated by IR emitters or reflective surfaces). Upon detection, the system triggered the dimming circuit, reducing glare for the hypothetical oncoming driver.

- Level 1: Servo positioned at 0° (Baseline).
- Level 2: Servo positioned at 45° (Mid-range adjustment).
- Level 3: Servo positioned at 90° (Maximum elevation).

Data Visualization: The I2C LCD provided real-time feedback, displaying the current "Mode" (Dim/Bright) and the active "Level" (1, 2, or 3). The I2C protocol significantly reduced wiring complexity, requiring only two data pins (SDA and SCL).

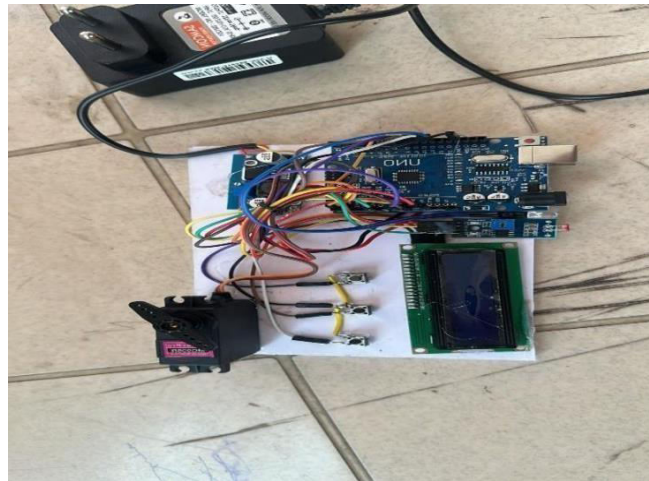


Fig.3 Prototype Setup of Adaptive Headlamp Control System

The results demonstrate that the Automatic Headlight Dimming System effectively addresses two major automotive challenges: night-time safety and ergonomic adaptability.

- **Sensing Accuracy:** The IR sensor proved to be a cost-effective solution for proximity detection; however, it was noted that ambient light and the reflectivity of the object could influence the detection range. In a real-world application, an LDR (Light Dependent Resistor) or a Photodiode might supplement the IR sensor to distinguish between heat signatures and actual visible light.
- **Mechanical Precision:** The use of a Servo Motor for seat leveling provided high torque and precise angular positioning. Unlike a standard DC motor, the servo's feedback loop ensured that the seat remained at the user-defined level regardless of minor vibrations.
- **User Interface:** The I2C LCD improved the user experience by eliminating guesswork. By utilizing the I2C communication bus, we optimized the microcontroller's I/O ports, leaving room for future expansions (such as adding ultrasonic sensors for reverse parking).

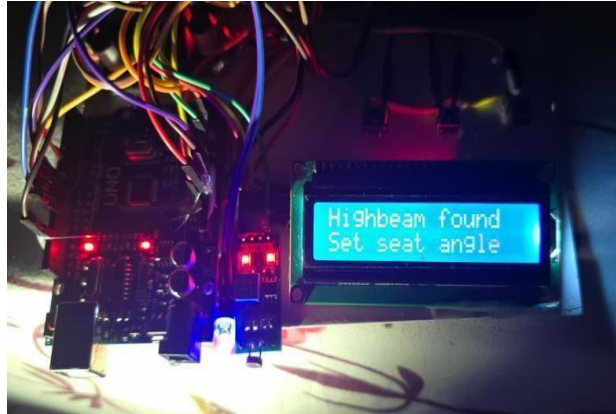


Fig.4 During working conditions

6 Conclusion

The automatic headlamp dip and dim system developed in this project demonstrates an effective approach to improving night-time driving safety through automation and intelligent control. By continuously monitoring ambient light conditions using an LDR sensor, the system dynamically switches between dip and dim modes to minimize glare for oncoming vehicles while maintaining adequate road illumination. The integration of a servo motor for headlamp or seat leveling ensures correct beam alignment under varying vehicle load and seating conditions, thereby enhancing visibility and driving comfort. The inclusion of an LCD display provides real-time system status and operational feedback to the driver, improving usability and awareness. The successful hardware and software implementation using an Arduino Uno proves that the proposed system is reliable, cost-effective, and easy to integrate into existing vehicle platforms. Overall, the project highlights the potential of microcontroller-based adaptive lighting systems as a practical solution for safer and more efficient automotive lighting applications.

7 Future Work

- Integration of camera or infrared sensors for accurate detection of oncoming vehicles.
- Replacement of LDR with advanced light and visibility sensors for better performance in fog and rain.
- Use of suspension or load sensors for more precise automatic headlamp leveling.
- Incorporation of CAN or Bluetooth communication for vehicle network integration and diagnostics.
- Upgrade of LCD to a graphical or digital instrument display.
- Implementation of machine learning or adaptive algorithms for intelligent headlamp control.
- Enhancement of system reliability through real-time fault detection and alerts.

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