Intelligent Headlight Beam Adjustment System

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Problem Statement

- Traditional vehicle headlights lack automatic beam adjustment, often causing glare for oncoming drivers and compromising road safety. Manual switching between high and low beam is prone to human error, especially in fast-moving or low-visibility conditions.
- Improper use of high beams can lead to temporary blindness for other drivers, increasing the risk of accidents. There is a need for an intelligent headlight system that can detect the presence and proximity of incoming vehicles.
- This project addresses the issue by integrating LDR sensors with a programmable LED matrix to enable automatic high-low beam switching.

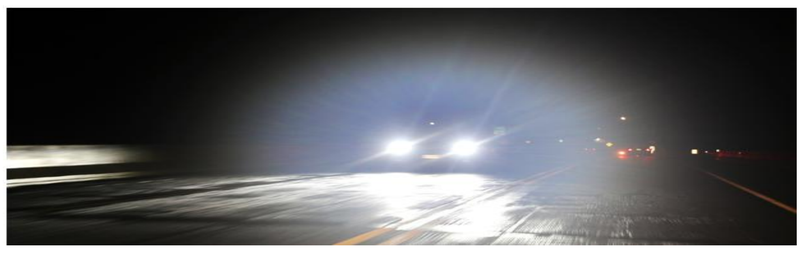


Figure 1: Problem faced by the driver

Objectives

- It is assumed that the LDR sensors, when used in combination with convex lenses, can effectively detect the presence of headlights from oncoming vehicles by responding to changes in light intensity.
- The LED matrix is assumed to be capable of replicating the functionality of a conventional headlight system through programmable brightness and pattern control. It is also assumed that the Arduino Mega can process sensor inputs in real time with minimal delay, ensuring smooth and responsive operation.
- Additionally, it is considered that external lighting conditions, such as streetlights or ambient light, will not significantly interfere with the LDR readings due to proper calibration and lens focusing.

Assumptions

- It is assumed that the convex lens effectively enhances the sensitivity of the LDR sensors by focusing incoming light rays directly onto their surface, allowing more accurate detection of oncoming vehicle headlights even from longer distances.
- The lens helps reduce false detections caused by scattered ambient light, improving the reliability of the system in real-world conditions. It is also assumed that the lens is properly aligned at its focal point relative to the LDR to ensure maximum light convergence.
- Additionally, it is considered that environmental factors such as rain or dust do not significantly hinder the optical performance of the convex lens. Overall, the lens integration is assumed to improve the calibration and functional accuracy of the LDR-based detection system.

Concept Design

- The project presents an adaptive headlight system using a LED matrix to emulate both high and low beam patterns with programmable control. A dedicated partition beneath the matrix houses LDR sensors.
- LDRs identify incoming headlight glare. To enhance the accuracy and range of light detection, each LDR is paired with a convex lens that focuses distant light directly onto the sensor surface. This focused light enables the system to respond earlier and more precisely.
- An Arduino Mega processes all sensor inputs and controls the LED matrix accordingly, automatically switching from high to low beam when necessary. Manual high-beam activation is also overridden in the presence of oncoming vehicles, ensuring adaptive, safe, and glare-free night driving.

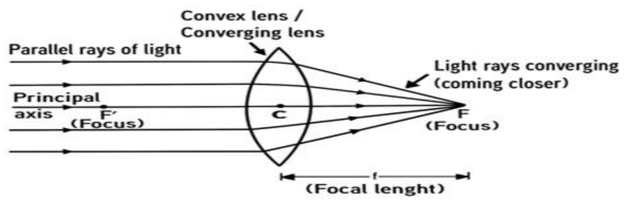


Figure 2: Convex Lens

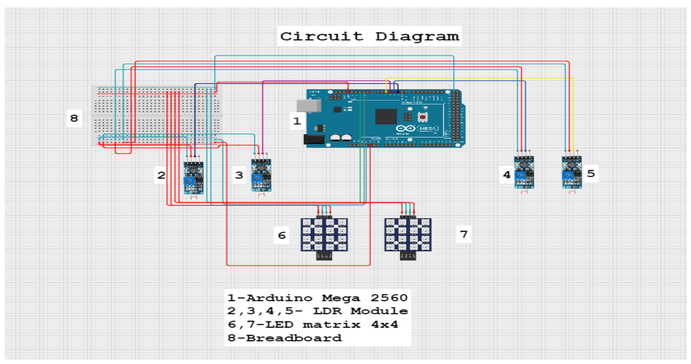


Figure 3: Circuit Diagram

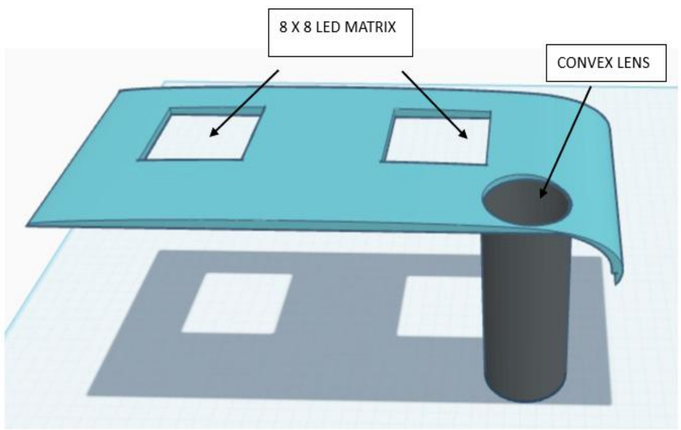
Pseudo Code

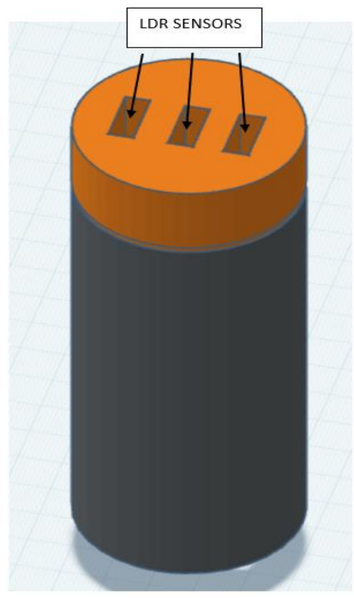
```
Begin
    Initialize pins and serial

Function high_beam():
    Turn ON ALL LEDs

Function low_beam():
    Turn ON LOWER LEDs
    Turn OFF UPPER LEDs

Loop:
    Read LDR_LEFT and LDR_RIGHT
      If LDR < threshold :
    low_beam()
    Else:
      high_beam()
    Delay
```

Bill of materials

	Part Name	Quantity	Unit Price (INR)	Total Price
2	Arduino Mega 2560	1	1250	1250
3	RGB LED matrix 8x8	2	183	366
4	Module LDR	4	69.5	278
5	Convex lens	2	125	250
6	HW battery	5	35.8	179
7	Wires (male to male + male to female+female to female)	20+20+20=60	3.33	200

Prototype





Outcomes and Inferences

Outcome :

- Developed a cost-effective prototype for automatic headlight beam adjustment using LDR sensors and a LED matrix.
- The system automatically switches between high and low beams based on vehicle proximity.
- Convex lens improves LDR sensor accuracy in low-light conditions.
- Demonstrated adaptive beam switching and manual override prevention for safety.

Inference :

- The developed prototype proves that affordable and efficient alternatives to luxury car headlight systems can be engineered using simple, accessible components
- The prototype has potential for real-world implementation in budget vehicles or as an aftermarket retrofit solution for improving road safety at night.

Literature Survey

1. **Nighttime Glare and Driving Performance: Research Findings -** Published in the National Highway Traffic Safety Administration Report (DOT HS 811 043, September 2008)
2. **Computer Vision-Based Adaptive Headlight Control Using Matrix LEDs -** Presented at the 5th International Conference on Smart Electronics and Communication (ICOSEC 2024), IEEE Xplore, ISBN: 979-8-3315-0440-3
3. **Automatic Brightness Control of Headlights Using LDR and Ultrasonic Sensors -** Published in Turkish Journal of Computer and Mathematics Education, Vol.12, No.14, 2021