IOT ENABLED SMART LIGHT SOLUTION FOR ELECTRIC VEHICLE

PROJECT REPORT

Abstract:

This project presents an intelligent headlight system designed to adaptively adjust its beam intensity and direction in real-time. Using a Light Dependent Resistor (LDR) sensor to detect the intensity of oncoming vehicle headlights, the system processes the data through a microcontroller, which controls a servo motor mechanism to reduce glare and enhance road visibility. It is an innovative, low-cost solution aimed at increasing road safety for nighttime driving, especially beneficial for smart and electric vehicles.

Objective:

1. To reduce the risk of nighttime road accidents caused by headlight glare.
2. To enhance visibility in real time without driver intervention.
3. To create a cost-effective and practical solution compatible with modern vehicle platforms.

Problem statement:

Nighttime driving remains a significant contributor to road accidents worldwide, primarily due to reduced visibility and the blinding glare from oncoming vehicle headlights. This glare can cause temporary visual impairment, delayed reaction times, and impaired decision-making, significantly increasing the risk of collisions.

Current automotive headlight systems typically operate at fixed intensities and beam patterns that do not adapt to changing environmental or traffic conditions. As a result, they either provide insufficient illumination in dark areas or cause excessive glare when approaching other vehicles. This inflexibility fails to address the dynamic nature of night driving environments.

METHODOLOGY:

System components -

- **LDR (** Light Dependent Resistor **)** : The Light Dependent Resistor (LDR) is a key sensing element in the adaptive headlight system. It is responsible for detecting the intensity of ambient and oncoming light. Based on this light intensity, the system decides whether to adjust the headlight brightness or direction.

- **Microcontroller(** Arduino uno **):** The microcontroller acts as the central processing unit of the adaptive headlight system. It receives real-time analog input from the LDR sensors, processes the data, and controls the output to actuate the headlight beam (intensity and orientation) using servo motors or dimmable LEDs.

- **Servo Motor:** The servo motor is used to mechanically adjust the orientation of the headlight beam in response to signals from the microcontroller. This adjustment helps direct the light away from the eyes of oncoming drivers, reducing glare and enhancing road safety.

- **LED (** Headlight Module) :The LED Headlight Module is responsible for producing the beam of light and adjusting its brightness dynamically based on input from the microcontroller. It ensures that the light intensity is suitable for both the driver and oncoming traffic, reducing glare while maintaining adequate road visibility.

- **Power Supply :**The power supply unit provides stable and regulated electrical power to all components of the adaptive headlight system, including the microcontroller, LDR sensors, servo motor, and LED headlight module. It ensures compatibility with standard automotive 12V DC systems and converts voltage as needed for individual components.

- **Buck Convertor :** The power supply unit provides stable and regulated electrical power to all components of the adaptive headlight system, including the microcontroller, LDR sensors, servo motor, and LED headlight module. It ensures compatibility with standard automotive 12V DC systems and converts voltage as needed for individual components.

Working Principle

- LDR sensors continuously monitor the intensity of oncoming lights.
- The microcontroller compares the sensed value against a threshold.
- If the intensity crosses the threshold, the servo motor alters the beam angle, and the light intensity is dimmed.

Once the incoming light disappears, the system reverts to the original beam configuration.

System Operation –

The Adaptive Headlight System operates based on real-time environmental light analysis and beam control, using sensor input and actuator feedback. The operation follows these key steps:

1. *Continuous Light Monitoring via LDR Sensors*

Light Dependent Resistors (LDRs) are strategically mounted on the front of the vehicle to detect the intensity of ambient and oncoming headlights.

These sensors provide analog voltage signals proportional to the light levels received.

2. Signal Processing by the Microcontroller

The microcontroller (Arduino uno) continuously reads the analog signals from the LDR sensors through its Analog-to-Digital Converter (ADC) pins.

It compares the current light intensity to a predefined threshold value, which is determined during system calibration.

3. ***Threshold-Based Decision Making***

If the incoming light intensity exceeds the threshold (indicating high glare from an approaching vehicle), the system automatically triggers adaptive measures:

The servo motor is actuated to alter the headlight beam angle, redirecting the light away from the oncoming driver’s line of sight.

Simultaneously, the LED headlight module is dimmed to reduce glare intensity, using PWM control.

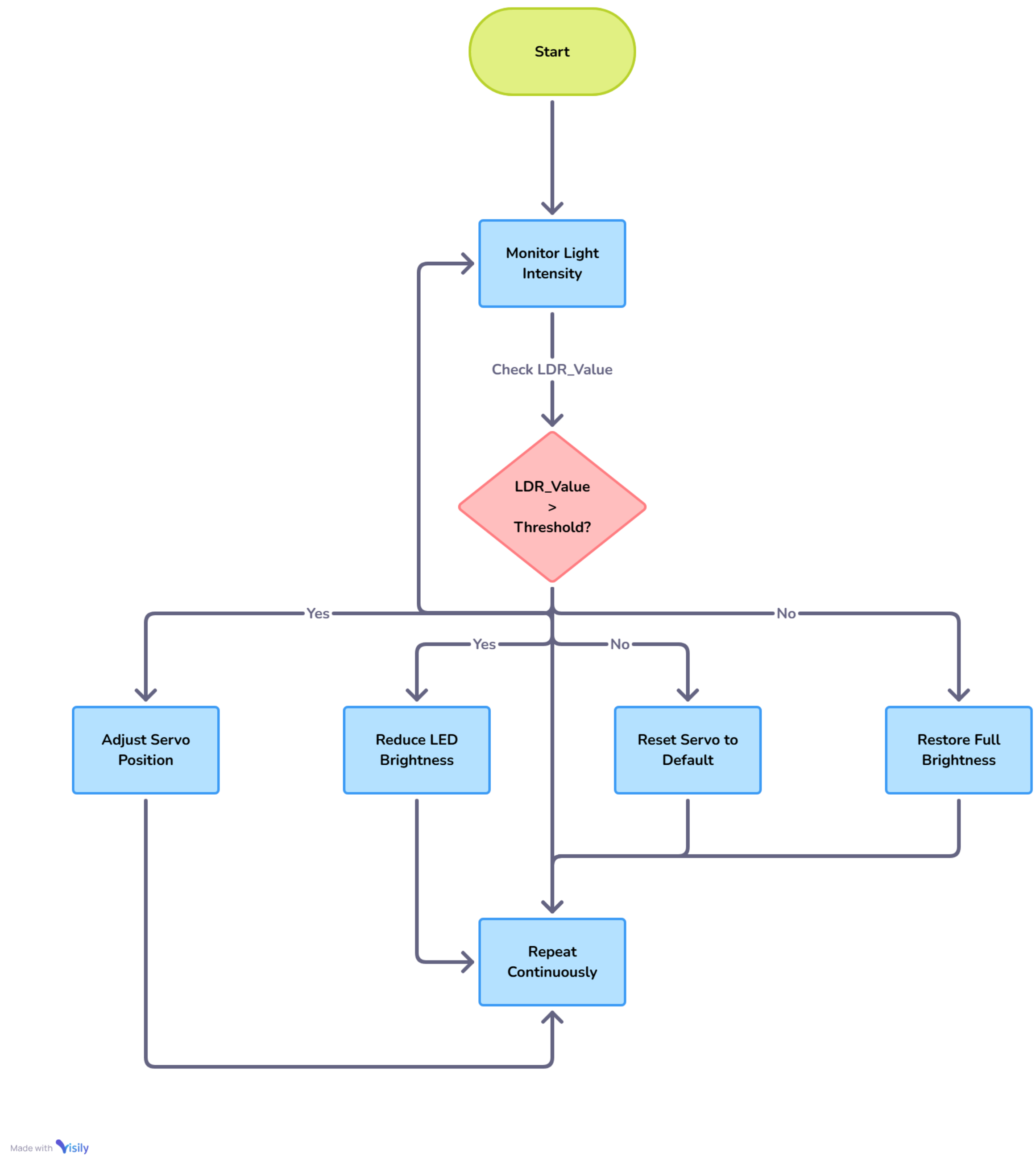
4. Restoration of Default State

Once the detected light intensity drops below the threshold (after the oncoming vehicle passes), the system:

Returns the headlight beam to its default angle, ensuring maximum forward visibility.

Restores full brightness of the LED headlight for optimal illumination.

FLOW CHART



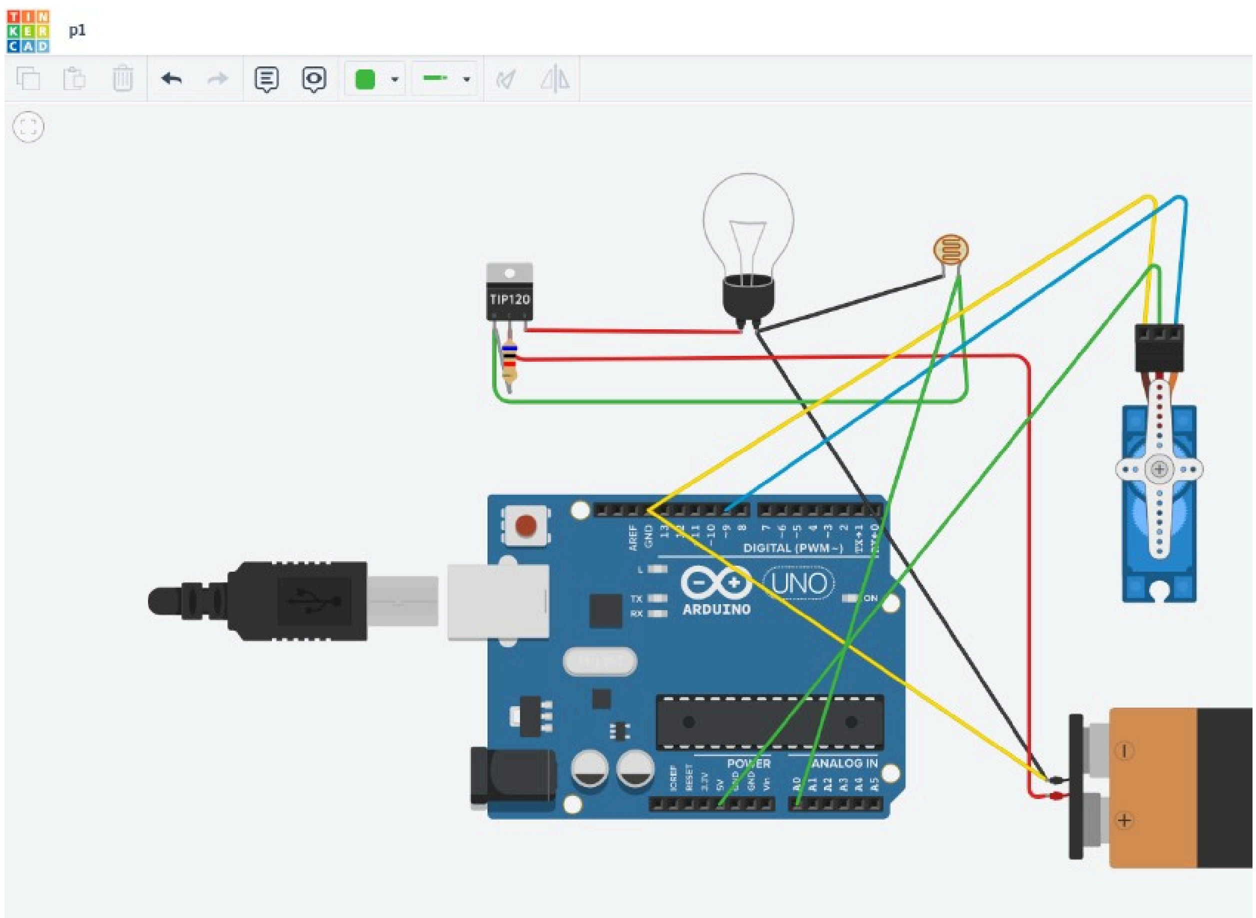
System Design

Circuit Design: Integration of LDRs with ADC pins of microcontroller.

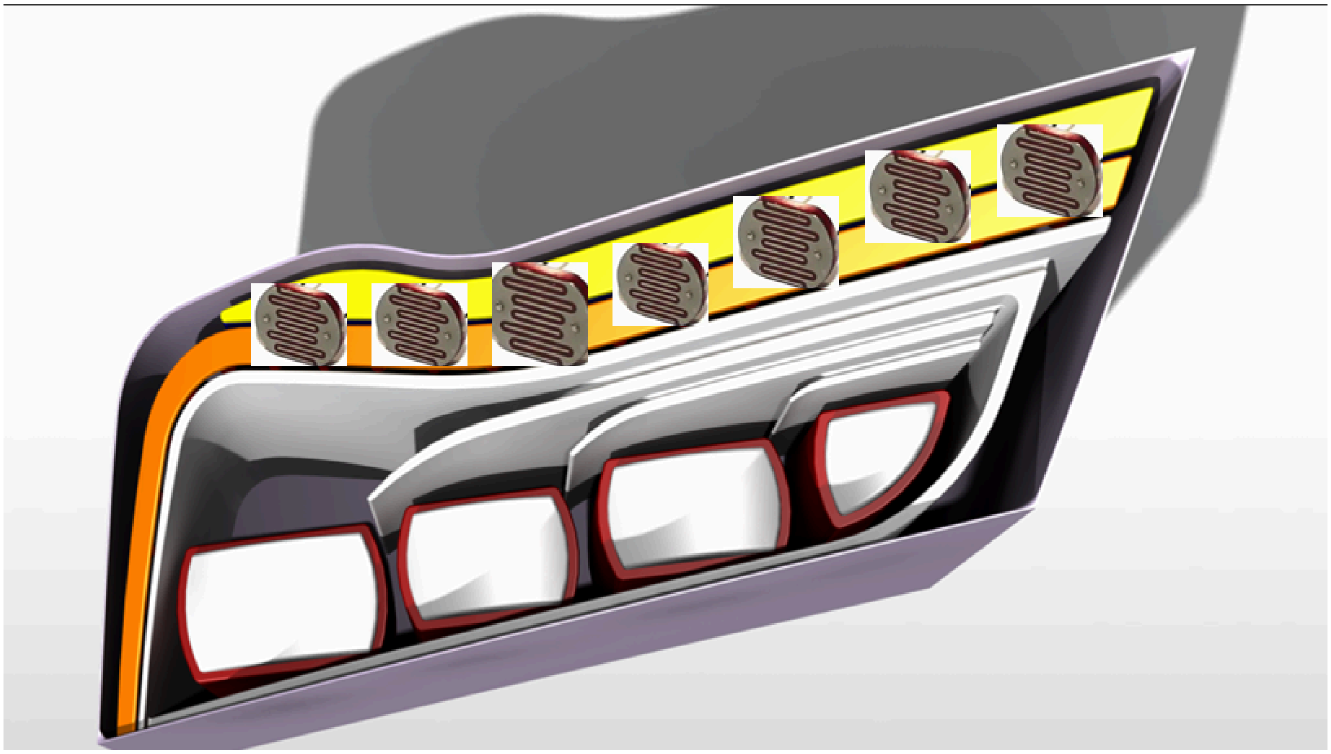
Mechanical Design: Headlight casing attached to servo-mounted brackets.

Software Logic: Coded algorithm to process intensity data and control servos and lights.

CIRCUIT DIAGRAM :



<u>Mechanical Design :</u>



<u>Software logic Code :</u>

```
#include <Servo.h>

Servo myservo;
const int ldrPin = A0;
const int servoPin = 9;
int ldrValue = 0;
int servoAngle = 0;

void setup() {
  myservo.attach(servoPin);
  Serial.begin(9600);
}

void loop() {
  ldrValue = analogRead(ldrPin);
  servoAngle = map(ldrValue, 0, 1023, 15, 0);
```

```
  servoAngle = constrain(servoAngle, 0, 15);
  myservo.write(servoAngle);
  Serial.print("LDR Value: ");
  Serial.print(ldrValue);
  Serial.print("\t Servo Angle: ");
  Serial.println(servoAngle);

  delay(100);
}
```

IMPLEMENTATION:

All major components of the adaptive headlight system are integrated within the headlight enclosure, forming a compact and modular design. This internal placement protects the system from dust, rain, and external damage while maintaining the aesthetic design of the vehicle.

- **LDR Sensors**: Mounted on the inner top surface of the headlight casing to detect oncoming light from various angles.

- **Servo Motor**: Fixed internally to the reflector or LED bracket, allowing controlled tilt of the beam angle.

- **Microcontroller Unit** (Arduino): Securely installed in the rear part of the headlight box with sufficient insulation.

- **Power Supply & Buck Converter:** Miniaturized and placed alongside the control unit to provide 5V regulated power for sensors and servo motors.

Limitations :

1. Bilateral Requirement :
The system is most effective when both vehicles are equipped with adaptive headlights. In traffic where only one vehicle has the system, its benefit is reduced.

2. Weather Sensitivity :
Environmental conditions such as fog, heavy rain, or snow can interfere with accurate light detection by the sensors.

3. Sensor Calibration :
LDR sensors require regular calibration to maintain accuracy over time due to potential sensor drift or environmental wear.

4. Component Heat & Space Constraints :
Since all components are integrated inside the headlight housing, the system may face:

Heat accumulation due to proximity of LEDs, servo motor, and controller

Limited space for component placement in compact headlight units
This necessitates thermal management and efficient internal layout design for long-term durability.

Protection from Environment :

To ensure durability and reliability in real-world automotive conditions, the system incorporates several protective features against environmental factors such as dust, water, and UV exposure:

1. IP65-Rated Enclosure
All critical components, including LDR sensors and the microcontroller, are housed within an IP65-rated sealed casing, providing protection against:

Dust ingress
Low-pressure water jets from any direction

2. UV-Resistant Shielding
A transparent, UV-resistant film is applied over the LDR sensors to:

Maintain light sensitivity
Protect against sunlight degradation and yellowing over time

3. Drainage & Ventilation
The headlight box is designed with:

Drain holes at the bottom to prevent water accumulation

Fine mesh filters at ventilation points to block debris while allowing airflow

Advantages:

1. Reduces glare for incoming drivers.
2. Increases safety without driver distraction.
3. Low-cost implementation using easily available components.
4. Supports eco-friendly vehicle initiatives.

Conclusion :

The Adaptive Headlight System provides a robust, practical, and affordable solution to a major traffic hazard. With minimal cost and simple installation, it has the potential to revolutionize vehicle lighting systems, especially in countries with poor lighting infrastructure. Its patentability lies in the unique combination of sensors and motion control to create a dynamic, responsive headlight system.