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DEPARTMENT OF ELECTRICAL/ELECTRONIC ENGINEERING

PROJECT TITLE: DEVELOPMENT OF AN INTELLIGENT HEADLIGHT CONTROL SYSTEM FOR ENHANCED ROAD SAFETY AND VISIBILTY

GROUP 3

MARCH 2025

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1. PROBLEM STATEMENT

Most drivers have become concerned about road safety and visibility especially during the nighttime. Conventional headlight systems are not designed to adapt to changing light conditions which leads to poor visibility, glare and increased risk of accidents. Also, the presence of oncoming vehicles can cause discomfort and distraction to drivers, especially to those who are blinded by intense brightness.

According to the Insurance Institute for Highway Safety (IIHS), half of the fatal car accidents on U.S. roads occur at night. What is more alarming, is that the number of accidents caused by glare from high beams account for 12% to 15% of all traffic accidents. W. Ackah in a journal published by Taylor and Francis Online, stated that most Ghanaian accidents occur during the night between the hours of 18:00GMT hours and 22:00GMT hours due to poor visibility.

IEEE has come up with a design of a working intelligent headlight system which uses Raspberry Pi. It uses devices like servo motors, LEDs and LDRs in addition to a Pi camera which is able to detect light from other vehicles and reduces the effect of glare by controlling the intensity of light. The project is still undergoing testing to determine how feasible it is.

The purpose of this project is to design, simulate and develop an intelligent headlight control system that adjusts its brightness and beam pattern in real-time based on ambient light conditions and the presence of oncoming vehicles. The control system aims to:

1. Reduce glare and discomfort caused by oncoming vehicle headlights.

2. Adapt to changing ambient light conditions.

3. Enhance road visibility and safety during nighttime driving.

4. Reduce nighttime accidents.

2. METHODOLOGY

2.1 HARDWARE AND SOFTWARE REQUIREMENTS

- Arduino Uno microcontroller
- Light Dependent Resistor (LDR)
- LEDs
- Resistors
- Breadboard
- Jumper cables
- Wokwi Simulation Software

2.2 PROCEDURE

The LDR was set up to produce certain numerical values in response to certain ambient illumination levels. These LDR values increase with decreasing incident illumination on the LDR and vice versa.

In order to have the effect of varying brightness, 4 LEDs were used such that, as ambient illumination reduces, more LEDs turn on hence increasing overall headlight brightness. For instance;

- At incident illumination of **“>= 100 lux”**, 1 LED turns on.
- At incident illumination of **“50 lux <= ambient illumination < 100 lux”**, 2 LEDs turn on.
- At incident illumination of **“15 lux<= ambient illumination < 50 lux”**, 3 LEDs turn on.
- At incident illumination of **“< 15 lux”**, 4 LEDs turn on.

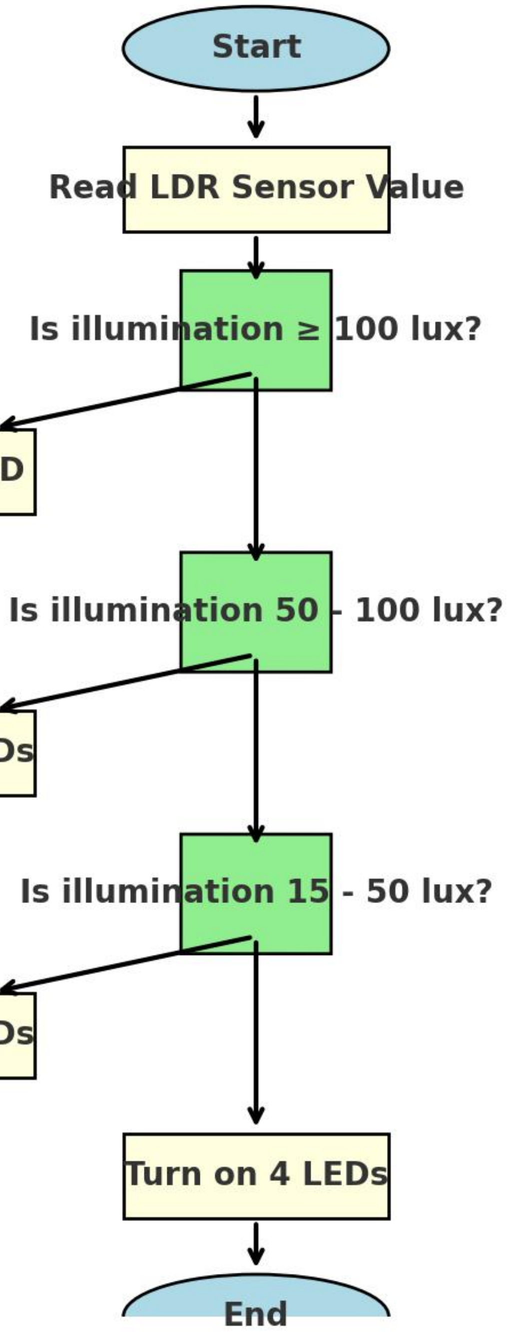

Fig 2.2.1 Flow chart of system operation

2.3 CIRCUIT DIAGRAM AND CODE

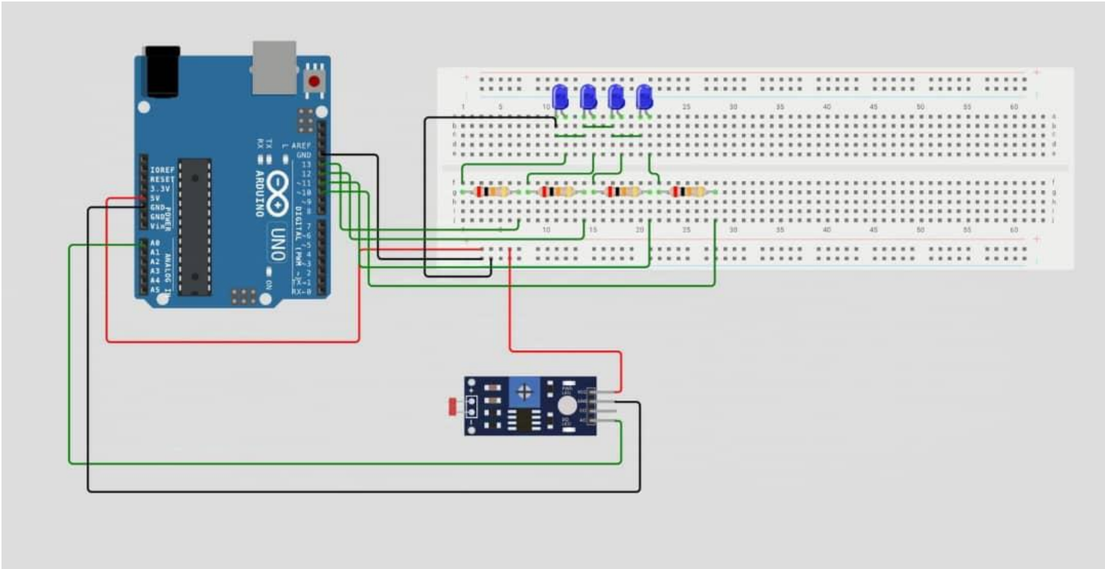

Fig 2.3.1 Intelligent Headlight Circuit diagram

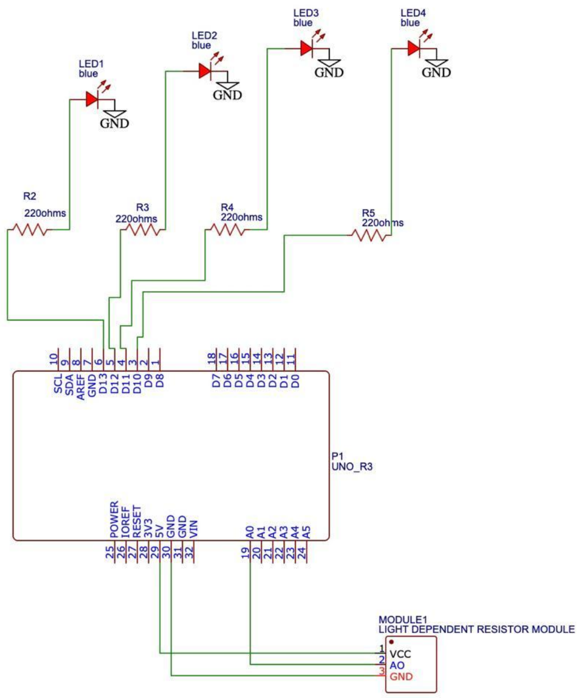

Fig 2.3.2 Intelligent Headlight Schematic Diagram

```
const int ldrPin = A0;  // LDR connected to analog pin A0
const int led1 = 13;    // LED1 connected to pin 13
const int led2 = 12;    // LED2 connected to pin 12
const int led3 = 11;    // LED3 connected to pin 11
const int led4 = 10;    // LED4 connected to pin 10

int ldrValue;

void setup() {
  Serial.begin(9600);       // Initialize serial communication at 9600 baud
  pinMode(led1, OUTPUT);    // Specify pin 13 as an output pin
  pinMode(led2, OUTPUT);    // Specify pin 12 as an output pin
  pinMode(led3, OUTPUT);    // Specify pin 11 as an output pin
  pinMode(led4, OUTPUT);    // Specify pin 10 as an output pin
}

void loop() {
  ldrValue = analogRead(ldrPin);   // Read the analog value from LDR
  Serial.print("LDR Value: ");
  Serial.println(ldrValue);        // Print the LDR value to Serial Monitor
  delay(500);                      // Delay for better readability

  if (ldrValue <= 511) {           // ambient illumination >= 100 lux
    digitalWrite(led1, HIGH);      // tunnels and underapsses
    digitalWrite(led2, LOW);       // presence of artificial lighting to maintain driver visibility
    digitalWrite(led3, LOW);
    digitalWrite(led4, LOW);
  }
```

Fig. 2.3.3a Image of written code

```
    digitalWrite(led3, LOW);
    digitalWrite(led4, LOW);
  }

  else if (ldrValue <= 632) {      // 50 lux <= ambient illumination < 100 lux
    digitalWrite(led1, HIGH);      // intersections and crosswalks
    digitalWrite(led2, HIGH);      // presence of brighter lighting for pedestrain safety
    digitalWrite(led3, LOW);
    digitalWrite(led4, LOW);
  }

  else if (ldrValue <= 808) {     // 15 lux <= ambient illumination < 50 lux
    digitalWrite(led1, HIGH);     // major, urban roads and highways
    digitalWrite(led2, HIGH);     // presence of uniform lighting to ensure visibility
    digitalWrite(led3, HIGH);
    digitalWrite(led4, LOW);
  }

  else {                          // ambient illumination < 15 lux
    digitalWrite(led1, HIGH);     // Rural, suburban roads
    digitalWrite(led2, HIGH);     // dim lighting, illuminated by moonlight and vehicle headlights
    digitalWrite(led3, HIGH);
    digitalWrite(led4, HIGH);
  }
}
```

Fig. 2.3.3b Image of written code

2.4 DETAILED OVERVIEW OF CODE

- *Line 1: "**const int ldrPin** = A0;"* assigns pin A0 to a constant, *ldrPin.*
- *Lines 2 to 5* assigns *pins 13, 12, 11 and 10* to constants named *led1, led2, led3, and led4, respectfully.*
- *Line 7: **int ldrValue*** defines at integer variable named ***ldrValue****.*
- The ***void setup()*** function in *Lines 9 to 15* sets up the Arduino board and LEDs by:
    - Initializing serial communication between the Arduino board and IDE at a rate of 9600 baud in *Line 10.*
    - Setting up the 4 LED pins as output pins in *Lines 11 to 14*.
    - This is done once.
- The ***void loop()*** function in *Lines 17 to 50* repeatedly does the following:
    - Reads the LDR analog value from ***pin A0*** that is stored in ***ldrPin*** and assigns it to the variable named, ***ldrValue*** in *Line **18.***
    - Displays the text, *"LDR Value: "* in the Arduino IDE's serial monitor in *Line 19*.
    - Displays the actual LDR numerical value in the serial monitor in *Line 20.*
    - Ensures the LDR values are displayed at intervals at 500 milliseconds or 0.5 seconds in *Line 21*.
    - Makes use of *if and else statements* to compare the LDR values to specified ranges of values in order to control the activation and deactivation of corresponding LEDs in lines 23 to 49.

3. TESTING AND RESULTS

The following results were obtained after testing:

- **Ambient Illumination > = 100 lux**
    - **Ambient condition:** Presence of artificial lighting to maintain driver visibility
    - **Location:** Tunnels and underpasses
    - **Result:** 1 of out 4 LEDs turns on

- **50 lux <= Ambient Illumination < 100 lux**
    - **Ambient condition:** Presence of artificial lighting to maintain for driver safety
    - **Location:** Intersections and crosswalks
    - **Result:** 2 of out 4 LEDs turns on

- **15 lux <= Ambient Illumination < 50 lux**
    - **Ambient condition:** Presence of uniform lighting to ensure visibility
    - **Location:** Major and urbans roads and highways
    - **Result:** 3 of out 4 LEDs turns on

- **Ambient Illumination < 15 lux**
    - **Ambient condition:** Dim lighting, illuminated by moonlight and other vehicle headlights
    - **Location:** Rural roads
    - **Result:** 4 of out 4 LEDs turns on

This shows that the system responds dynamically to changing illumination levels which enhances visibility while reducing excessive brightness and glare.

4. CHALLENGES

During implementation, the following challenge was encountered.

1. The brightness of a single LED could not be varied so 4 LEDs were used to obtain the effect of varying brightness.

5. CONCLUSION

The intelligent headlight control system is an innovative way of reducing nighttime accidents caused by visibility issues on roads.

The project described in this paper is a very simple implementation of what is being done in real world industries and hence would require multiple tests in specified ambient conditions in order to improve overall efficiency and performance.

In addition to iterative testing, the integration of AI and cameras into the adaptive headlight would greatly improve its response to ambient lighting and detection of oncoming vehicles.