

# LightSync: An Adaptive Headlight System for Cars

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**Abstract**—While driving at night headlights play a very important role. But the same headlight in high beams when encountered from the opposite side causes temporary blindness to the driver and furthermore, accidents. Changing the light beam intensity manually may be inaccurate at times or not performed at all. This report contains an approach to automate the change in brightness level of headlights in accordance with the distance and light intensity from the incoming vehicle using a prototype consisting of LEDs, LDRs, ultrasonic sensors all of which were used with Arduino Uno boards.

**Keywords**—intensity, LEDs, LDRs, ultrasonic sensors, Arduino Uno

## I. INTRODUCTION

Accidents during night have been very common in the present scenario and one of the main reasons is the high beam from modern headlights. This high beam when coming from the opposite direction causes temporary blindness to the driver because of high glare and it may result in accidents and collisions. According to a survey conducted, more than 30% of the accidents caused during night are due to headlight glare. The unwanted use of high beams may lead to unnecessary crashes. It also says that 26.5% alone use dippers (low beam) correctly out of 73.83%, remaining keep the high beam constantly or only dim for a few seconds [1]. The current technologies tackling the issues include Audi and Volvo's LED matrix systems that calculate the solid angle of the incoming cars and turn off the LED projector beams from that part of the matrix.

Inspired by this, this problem has been approached on a simpler level. Ultrasonic and LDR sensors have been used to detect any light and object coming from a particular direction and then based on predefined threshold conditions, turned the brightness of the appropriate LED strip down smoothly. 6 LED strips facing the same directions (currently for simplicity) were used along with the sensors facing 4 directions to selectively lower down the brightness of only the strip(s) facing the incoming car so that the rest of the domain is clearly visible.

## II. THEORY

The ultrasonic sensors use the time-to-distance conversion to detect distance between itself and an object. The Trig (trigger) pin emits ultrasonic waves, which travel in air and are reflected after encountering an object and received by the Echo pin which produces a pulse on doing so. The time taken to travel is calculated by the sensor, and since the speed of ultrasonic waves is same as that of sound in air, which is a known quantity, the distance is calculated as the product of speed and time.

The light dependent resistor (LDR) has a property of changing resistance as per the amount of light falling on it. Its

resistance is inversely proportional to the light intensity. Arduino board cannot measure the resistance; therefore, a resistor is connected along with the LDR to create a voltage drop for the board to measure it [2].

## III. MATERIALS USED

- 2 Arduino UNO boards
- 4 light dependent resistors (LDR)
- 4 HC-SR04 ultrasonic sensors
- 6 WS2812B LED strips having 6 LEDs each
- 1 breadboard
- Connecting wires
- 4 10 k $\Omega$  resistors

## IV. PROCEDURE

1. The blinking behavior of a single LED strip was studied with an LDR sensor, an IR (Infrared) sensor [3], and an ultrasonic sensor [4] individually with the help of Arduino Uno board.
2. IR sensor was not included in the final components because of its lower range and detection property of infrared light only.
3. The blinking was studied with an integrated system of an LDR sensor and ultrasonic sensor using the circuit shown in Fig.1.

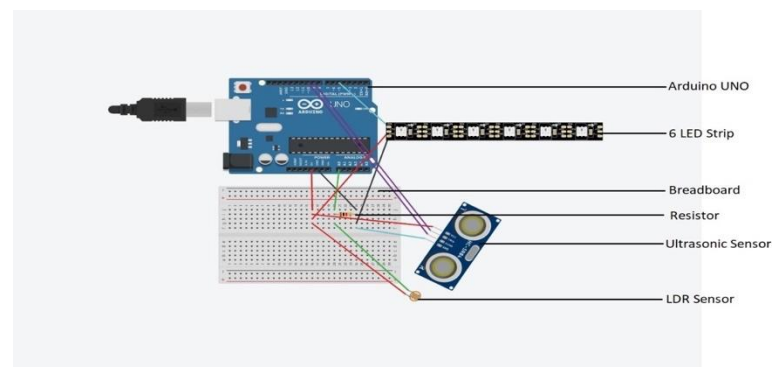


Fig. 1. Circuit diagram for controlling an LED strip using an LDR and an ultrasonic sensor made using Tinker CAD This is the fundamental unit of the final prototype and would be used in the same multiple times.

4. The output values of LDR and ultrasonic sensors were studied using the serial monitor and threshold values were decided to increase or decrease the brightness values of the LEDs accordingly.
5. The Adafruit\_NeoPixel library [5] was used to modify the Arduino code to gradually fade in or fade out the values instead of an abrupt change. It was further calibrated to switch off the first three LEDs in case of excess light and less distance.

6. The same circuit was arranged such that all 6 LED strips are included. The connections were made such that the 1st strip, and a parallel combination of 2nd and 3rd strips were controlled by one Arduino, and a parallel combination of 4th and 5th strips, and the 6th strip was controlled by the other Arduino. The whole arrangement was set on a mount board.
7. Code for the prototype is attached below:  
<https://drive.google.com/file/d/1Ojft0Txyt1-knCGz3RToS937omhqfkBM/view?usp=sharing>

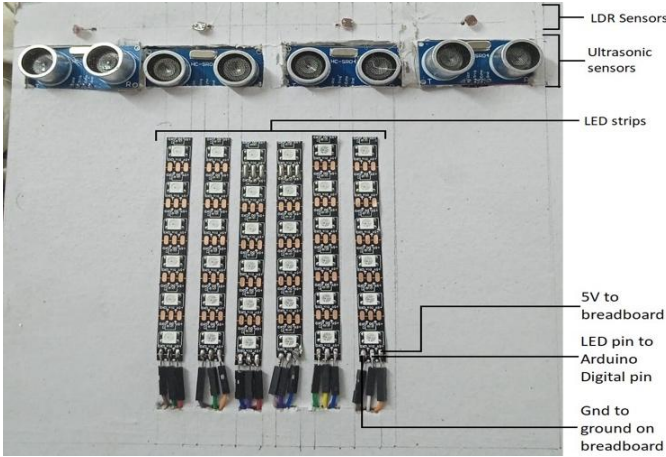


Fig. 2. The final prototype consisting of exposed sensors and arranged LED strips.

## V. RESULTS

- A. The ultrasonic sensor measures the distance of the phone and the LDR sensor detects the light from flashlight. When the phone is brought closer in the direction of a particular pair of sensors, the corresponding values of distance decrease and light levels increase. On satisfying the predefined conditions according to the code, all LEDs of the respective strip(s) dim.

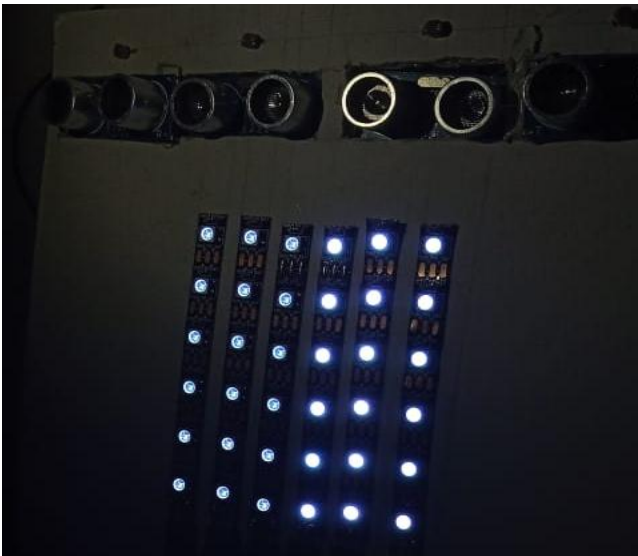


Fig. 3. Selective dimming: only the first three strips are dim, and the rest continue to be bright since source of light is closer to left-most sensors.

- B. Another situation of multiple vehicles approaching from different directions is dealt with switching off completely the first half of the headlights while keeping the rest of them switched on at dim mode.

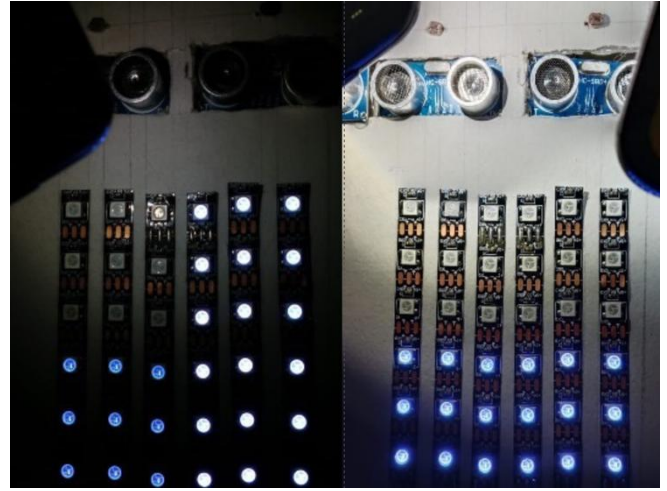


Fig. 4. When the source of light is too close with high intensity, the first three LEDs of each strip would completely switch off selectively. The first picture has one light source and the second has two.

- C. Random values of resistors were connected with the LDR gave fluctuating outputs, thus, the relation between LDR and resistor along with it was explored [2], and finally 10 k $\Omega$  rendered the best output, and was hence chosen for all LDRs.

## VI. DISCUSSION

The Fig. 3 depicts the scenario of two cars approaching each other: as they come closer, the light from the first one dims so as to not cause a glare on the driver of the other, and regains its brightness once the car has passed. Fig. 4 is analogous to multiple vehicles approaching from different directions: only a lower beam of light remains to keep the vehicle visible while reducing glare in all the directions.

The circuit was mainly studied using a singular amount of all major components. The final assembly required taking multiple connections on the breadboard such as that of 5 V, ground and LED pins for parallel connections. The fading process was smoother with the higher resistor of 10 k $\Omega$  because, since the resistor and LDR are in series, the potential drop across the resistor increases and since Arduino Uno detects voltage, it does so accurately.

## VII. CONCLUSION

Experimental results demonstrate that the integrated system effectively responds to changes in distance and light intensity. The primary goal of the project was to mitigate the issue of temporary blindness caused by high-beam headlights during night-time driving, which has been a significant contributor to road accidents. Through meticulous experimentation and calibration, we achieved the appropriate adjustment of headlight brightness, ensuring optimal visibility.

The proposed solution successfully employs LDR and ultrasonic sensors to detect the flashlight intensity and the distance between the mobile and our system, respectively and adjusts the brightness of the LED strips depending on the threshold values and conditions written in our Arduino code. This can be applied in the headlight system of cars to detect the oncoming vehicles. The LDR would measure the light intensity, the ultrasonic waves would measure the distance between the vehicles, and our solution would intelligently detect the direction from which the vehicle is coming and adjust the headlight brightness by dimming or shutting off the corresponding LED strip as per the code. We will need to recalibrate the threshold values and the conditional statements based on real-life case scenarios.

This outcome confirms the project's success in solving the problem statement and achieving its intended purpose, which was to minimize the glare faced by the opposite driver. In this way, our project contributes to enhancing road safety during night time driving.

Future plans could include incorporating mechanical arrangement of mirror to spread the direction of the beam while also dimming the intensity of the headlights using the aforementioned method.

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