

Automatic Headlight Dimmer and Curve Lane Detection for Intelligent Transportation Systems

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ABSTRACT In recent years, humankind has made remarkable progress in the transportation system. Specifically, advanced sensors are installed at both the infrastructure and the vehicles to provide improved situational awareness and facilitate machine intelligence during the decision-making while driving, realizing the Intelligent Transportation Systems (ITS). Among the various issues, the prediction of the vehicle motion and behavior is a crucial topic, since it provides critical information to the decision-making of both individual vehicles and the transportation control center. As a result, there have been many recent studies on vehicle trajectory tracking and behaviour prediction. The emergence of intelligent connected vehicles is expected to contribute to resolving traffic congestion and safety problems; however, it is inevitable that ICV safety issues in mixed traffic will be a critical challenge. Numerical simulation of scenarios involving a mix of different driving profiles is expected to be an important safety assessment tool in the process of testing and validating ICVs, especially regarding extreme scenarios, including car collisions, which are rarely captured in real-world datasets. Collisions can be avoided by detecting the driving patterns. Vehicle behavior prediction provides important information for decision-making in modern intelligent transportation systems. People with different driving styles have considerably different driving behaviors and hence exhibit different behavior tendency. However, most existing prediction methods do not consider the different tendencies in driving styles and apply the same model to all vehicles.

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I. INTRODUCTION

Light is electromagnetic radiation within a certain portion of the electromagnetic spectrum. The word usually refers to visible light, which is visible to the human eye and it is responsible for the sense of sight. Visible light is usually defined as having wavelengths in the range of 400–700 nanometers (nm), or 400×10^{-9} m to 700×10^{-9} m, between the infrared (with longer wavelengths) and the ultraviolet (with shorter wavelengths). Light can be produced by nature or by humans. "Artificial" light is typically produced by lighting systems that transform electrical energy into light. The human eye is a very sensitive organ. It works almost an entire day without any rest. The human eyes are adaptable to a particular range of vision. There are two visions namely the scotopic and photopic vision. Human eyes actually behave differently in different conditions. During bright surroundings, our eyes can resist up to 3 cd/m². This is the photopic vision. During dark and unlit conditions, our eye switches to scotopic vision which has a range of 30-45 μ cd/m². It takes 4 seconds for our eyes to change from photopic vision to scotopic vision. This is also an example of Troxler effect [1]. As the brightness increases, the strain to focus on an object increases. This will increase the response time of that person.

The requirement of headlight is very common during night travel. The same headlight which assists the driver for better vision during night travel is also responsible for many accidents that are being caused. The driver has the control of the headlight which can be switched from high beam (bright) to low beam (dim). The headlight has to be adjusted according to the light requirement by the driver [2]. During pitch black conditions where there are no other sources of light, high beam is used. In all other cases, low beam is preferred. But in a two- way traffic, there are vehicles plying on both sides of the road. So, when the bright light from the headlight of a vehicle coming from the opposite direction falls on a person, it glares him for a certain amount of time. This causes disorientation to that driver. This discomfort will result in involuntary closing of the driver's eyes momentarily. This fraction of distraction is the prime cause of many road accidents [3]. The prototype that has been designed to reduce this problem by actually dimming down the bright headlight of our vehicle to low beam automatically when it senses a vehicle at close proximity approaching from the other

direction. The entire working of the dimmer is a simple electronic circuitry arrangement which senses and switches the headlight according to the conditions required [4].

Motorists face a huge problem due to high beam light which falls directly onto their eyes when driving at night or during foggy conditions [10]. There is medical effect associated with these phenomena. This effect includes temporary blindness, glare, fading effect of image and sometimes causing accident leading to loss of many lives. This effect contributes to a terminology known as Troxler Effect. Troxler effect is used to describe a kind of temporary blindness. It is otherwise known as the 'fading effect'. A study shows that if our eyes are exposed to a very bright light source of around 10,000 lumens, we experience a glare [5]. This glare is produced due to over exposure of the rods and cones inside our eye. Even after the source of glare is removed, an after-image remains in our eye that creates a blind spot. This phenomenon is called Troxler effect. This means that the driver's reaction time is increased by 1.4 seconds. For example, let us assume a motorist travelling at 60 miles per hour takes 0.5 seconds to react to a hazard and will stop within 41 feet. Due to Troxler effect, the same person travelling under the same conditions will take 0.9 seconds longer to react and hence will come to a complete halt only at 123 feet [6]. There is a huge difference of 82 feet. This is more than enough to cause a disaster on the road[12]. This Troxler effect is across all ages. Any one exposed to sudden bright light experiences this Troxler effect. Hence there is a need to design and construct a prototype of this device that automatically dims the headlights for on-coming vehicles using light dependent resistor sensing technique to help solve this problem[13].

The proposed system aims to enhance driving safety by implementing an Automatic Headlight Dimmer and Curve Road Detection system using IoT technology[8]. The system combines real-time curve detection with adaptive headlight control[7], ensuring optimal visibility and improved safety during night driving[14]. Our system detects the obstacle in front of the vehicle and dims the light according to certain distances as high, medium and low with a buzzer alarm. Also when a curve road is detected, vehicle automatically slows down. The benefits of the system are:

1. **Improved Safety:** The automatic adjustment of headlights based on road curves and ambient light conditions ensures optimal visibility, reducing the risk of accidents.
2. **Real-time Adaptability:** The integrated model continuously monitors road conditions and adjusts the headlights in real-time, providing immediate responses to changing environments.
3. **Energy Efficiency:** The system optimizes the use of headlights by adjusting their intensity, resulting in reduced power consumption and extended bulb lifespan.
4. **Remote Monitoring and Control:** The IoT integration enables remote access and control, allowing users to monitor the system's status, adjust settings, and receive notifications from anywhere.
5. **Cost-Effective Solution:** Retrofitting the proposed system into existing vehicles eliminates the need for purchasing new vehicles with built-in adaptive headlight systems.

Direct monitoring was conducted which gives a detail population count and measure of aves that are of conservation interest, such as types of species, abundance of single species, the species is local or migrant.)

The flow of paper are classified as problem formulation with exiting state of art in introduction section. Section two contain design and algorithm of automatic dimmer and curve road detection system. Section Three discussed results with different types of experimental setup, evaluation of conduction of experiment and exiting state of art with comparison of experimental setup with previous work.

II. MATERIAL AND METHODS

This section presents the Design and analyze of automatic headlight dimmer and curve road detection for intelligent transport system methodology.

Phase I: Automatic Headlight Dimmer and Curve Road Detection System Design by utilizing IoT technologies

System design is the process of defining the architecture, components, modules, interfaces and data for a system to satisfy specified requirements. It is the application of systems theory to product development. There is some overlap with the disciplines of system analysis, system architecture and systems engineering.

The proposed system for the topic of automatic headlight dimmer and curve road detection using IoT aims to enhance road safety and driver convenience by utilizing IoT technologies and intelligent algorithms. An ambient light sensor is used to detect the lighting conditions in the surrounding environment. A microcontroller or IoT device is employed to process the sensor data and control the headlights. The system automatically adjusts the brightness of the vehicle's headlights based on the ambient light levels, ensuring optimal visibility without causing discomfort to oncoming drivers. A combination of sensors, such as a gyroscope and accelerometer, are used to detect the vehicle's motion and orientation. The IoT device processes the sensor data in real-time to identify curve road conditions. Machine learning algorithms or pre-defined models can be employed to analyze the sensor data and detect curves accurately.

The architecture of the auto dimmer and curve lane detection consists of:

ESP8266: The ESP8266 is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability[7]. This small module allows make simple TCP/IP connections using Hayes-style commands. The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume.

Ultrasonic Sensor: The SR04 ultrasonic sensor is a popular module used for distance measurement in various projects[9]. It utilizes ultrasonic waves to measure distances accurately and is commonly used in robotics, automation, and proximity sensing applications. The SR04 sensor works based on the time-of-flight principle. It emits ultrasonic waves (inaudible to human ears) from its transmitter and measures the time it takes for the waves to bounce back after hitting an object.

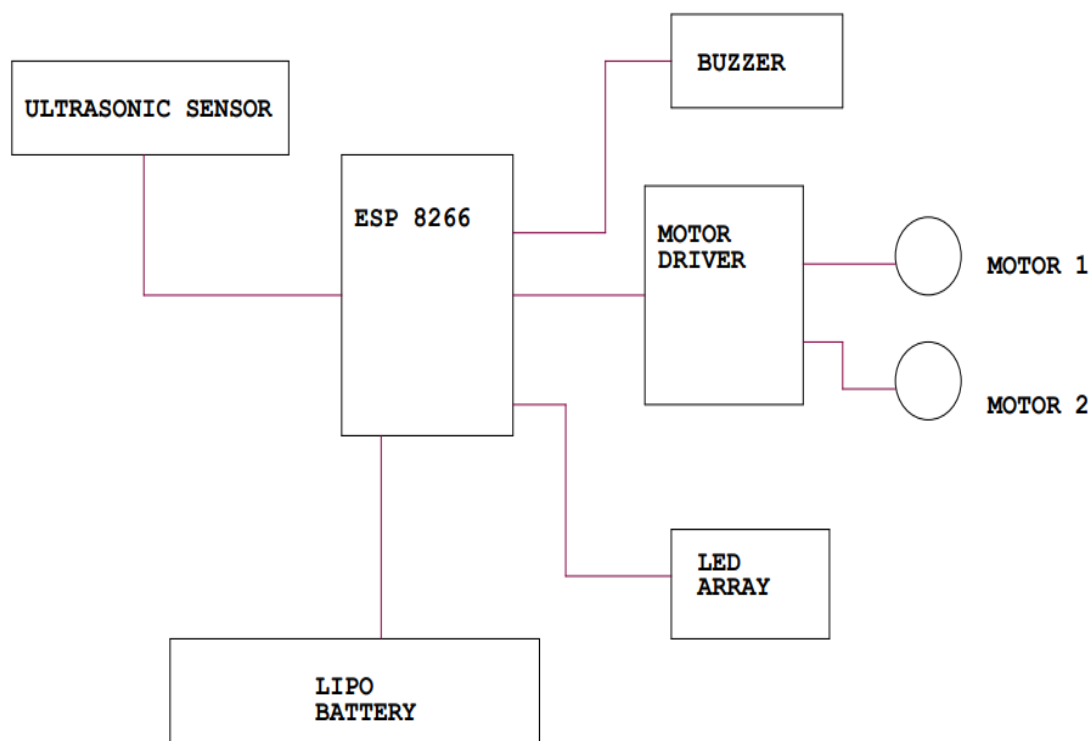


Figure 1: The flow of the methodology

LiPo Battery: A LiPo (Lithium Polymer) battery is a rechargeable battery type that is widely used in a variety of electronic devices, including smartphones, tablets, drones, RC vehicles, portable gaming consoles, and more. LiPo batteries are known for their high energy density, lightweight design, and ability to deliver high discharge rates. LiPo batteries offer a high energy density, meaning they can store a significant amount of energy in a small and lightweight package.

Motor Driver: The L298 is a popular dual H-bridge motor driver integrated circuit (IC) that allows you to control and drive DC motors or stepper motors with ease. It provides bidirectional control for two motors, enabling forward and reverse motion as well as speed control. The L298 has two H-bridge circuits, allowing independent control of two motors.

LED Array: An LED (Light-Emitting Diode) array is a collection of multiple LEDs arranged in a specific pattern or configuration. LED arrays are commonly used in various applications, including displays, lighting fixtures, signage, and visual communication systems.

Buzzer: Buzzer is an audio signaling device. The typical uses of buzzers are for alarms, timers and confirmation of user input such as a mouse click or keystroke. The project used an electronic type of buzzer which is a piezoelectric element that driven by a micro-controller signal.

Phase II: Intelligent algorithms and Circuit diagram

System implementation is a crucial phase in the software development life cycle. It involves bringing the system or software to life and making it available for its intended purpose. The goal of system implementation is to ensure that the system is deployed in a way that meets the requirements of its users and stakeholders.

Implementation process for automatic dimmer and curve lane detection is to help the drivers to

overcome the obstacle coming in front of the vehicle and also help the drivers to control the accidents occurring especially during nights. This process requires the integration of various components such as ESP8266 module and user interfaces to create a fully functional system.

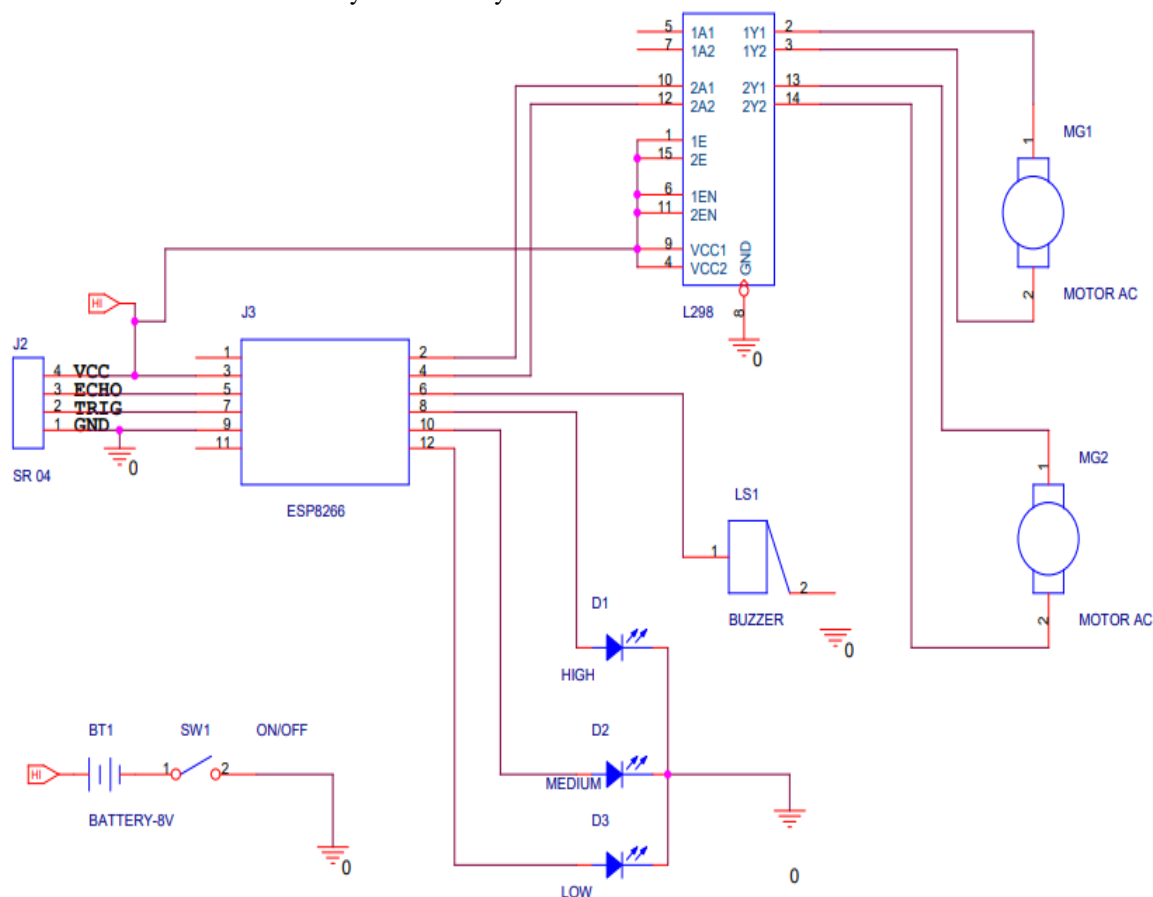


Figure 4.1: Circuit Diagram

The above circuit consists of seven modules namely L298 Motor driver, SR 04 ultrasonic sensor, two LiPo batteries, 60 RPM BO motor, three LEDs, Buzzer and ESP8266 common ground connection is made with seven modules is provided by adapter. Two motors are connected to the motor driver. An ultrasonic sensor is placed on ESP8266. ESP8266 is a low- cost wi-fi microcontroller chip that can be programmed to connect to the internet and perform various task. It is commonly used in IoT (Internet of Things) projects and can be easily programmed using the Arduino IDE. The basic components of the circuit includes a buzzer, an LED array and LiPo batteries. The two ends of the ultrasonic sensors represents the transmitter and the receiver. As a signal from the transmitter detects an obstacle infront of the vehicle, the reflecting signal is captured by the receiver and shows the output.

IMPLEMENTATION STEPS

The algorithm used in this project:

The first step in programming the Arduino board is downloading and installing the Arduino IDE. The ESP8266 have typically programmed the usage of a dialect of capabilities from the programming languages C and C++. ESP8266 is programmed for sending the SMS to the user when the obstacle is detected at a certain distance.

ESP8266 Programming: Circuit Designing and Connections:

Step 1: A circuit for connecting different modules is created using EasyEDA website. A power supply is connected to LM2569S.

Step 2: The chip has two analog input channels A and B and it designed for high-precision electronic scale applications.

Step 3: On chip power supply regulator to provide analog power for the ADC and the sensor. Red, black, green and white wire of load cell is connected to E+, E-, A- and A+ port of board respectively.

Step 4: The amplifier unit was attached to D2 and pin DT connected to D1 of ESP8266. The operation supply voltage of the amplifier unit is 4.8 to 5.5V. So, the Vcc pin of the unit is connected to the ESP8266 5V power pin.

Step 5: The output digital signal from that sensor is (D out) pins connect to the ESP8266 A0 pin. Vcc pin of the sensor was connected to the ESP8266 5V pin as the sensor operates 5V DC and attaches GND pin to the ground pin on the ESP8266. Pin D12, D13 are connected with piezo buzzer, warning led respectively.

Step 6: Connect the GSM Module with 9V/12V external Power Supply. Only the Tx, Rx and GND pin of Sim800 Modem is connected to ESP8266. So, connect Tx & Rx to Pin No. D5 and D6 of ESP8266 respectively. Using this modem, we will be able to send and receive messages.

Mounting Circuit on a Surface: The whole circuit is placed on a wooden surface to assemble the lighting and buzzing components. Transmitter and receiver are the two ultrasonic sensors used for the detection of an obstacle. Once our vehicle closes on to an obstacle lights will be switched to high position with a buzzer signal.

III. RESULTS

The current challenges of IoT implementation are overwhelming, attributable to the highly complex and unique characteristics of IoT applications. This mandates different test scenarios for normal usage, peak points, and day-long simulations to ascertain if these applications ensure total performance and scalability of the IoT architecture. Our testing protocols are intelligently created using a combination of Arduino IDE, devices, and processes, which stretch the capabilities of IoT applications in the most demanding environments. We integrate various protocols and platforms to deliver two key benefits to transformative enterprises.

Phase I: Experimental setups for different Types of Tests

Security Testing

Handling an onslaught of data is fundamental to IoT operations, and therefore, enterprises must conduct security testing to eliminate vulnerabilities and maintain the integrity of data protection, encryption/decryption, device identification and authentication among more. IoT Security testing is a process of testing IoT devices to find security vulnerabilities that hackers could exploit to access your network, modify your data, or steal your information. This can lead to significant financial losses, identity theft, and damage to the reputation of your business [11].

Performance Testing

This covers real-time and far more cumbersome aspects, such as load testing, streaming analytics, time-bound outputs, and timing analysis, to validate and ensure consistent performance of data reading, writing, and data retrieval. Performance testing is the practice of evaluating how a system performs in terms of responsiveness and stability under particular workload. Different performance testing types measures according to benchmarks and standards. Performance testing gives developers the diagnostic information they need to eliminate bottlenecks.

Table 5.1: Unit test cases

Test Case	Description	Expected Result	Obtained Result
1	Obstacle detected by the sensor	Slows down the vehicle	Slows down the vehicle
2	Vehicle detected at the certain distance	Alert the user through Buzzer and Message	Alert the user through Buzzer and Message

Compatibility Testing

This testing assesses if the existing working combination of hardware, software, protocols, and operating systems fall on the IoT interoperability radar, and are compatible with the standards and specifications of conventional IoT industrial framework. There are two types of Compatibility testing forward and backward testing. Forward Compatibility Testing is a process to verify the behavior and compatibility of the developed hardware or software with the newer versions of the hardware or software. Backward Compatibility Testing is a technique to verify the behavior and compatibility of the developed hardware or software with older versions of the hardware or software.

Functional Testing

This examines the qualitative and quantitative functional deliverability of deployed IoT applications in the actual conditions. Aspects, like network size, environment conditions, and topologies, are put to test. The key for IoT functional testing is a simulated real-life environment using real devices or simulators to test those core components. IoT technologies continue to emerge rapidly, and every use case differs as far as what would be considered the functional core components. Each device is and will be unique.

Regulatory Testing

This testing determines the compliance of IoT applications with privacy regulations. Compliance testing or conformance testing is a process conducted to determine if a process, product, or service meets a set of requirements, based on internal or external standards or regulations.

Scalability Testing

This includes the testing of all functional and non-functional use cases to ascertain whether the system is easy to scale to accommodate future upgrades. A scalability test is a type of load testing that measures the application's ability to scale up or down as a reaction to an increase in the number of users. In other words, it tests how the system is going to perform during a sudden spike or fall of user request loads. It is also referred to as testing, as such, it is focused on the behavior of the application when deployed to a larger system or tested under excess load [11].

The outcomes of this proposed system are as followed. The proposed system, in which the user gets an alert message when an obstacle is found near the vehicle from a certain distance. Also when a vehicle to our opposite reaches a certain distance the LED switches to three modes of light- high, medium and low. As the opposite vehicle reaches the closing distance with our vehicle, a buzzer alarm will be signaled so that the driver gets alerted due to this.

Phase II: Evaluation of Results working model

The circuit had been designed to be a working model. Until the vehicle is encountered by an opposite vehicle, it can travel with high beam. Once it encounters an opposite vehicle, each of the two vehicles senses the opposite vehicle's light. Thus, if either of the vehicles are using high beam, it switches to low beam. If the headlight is already in low beam, then no change occurs. As the vehicles cross each other, the intensity of light falling on the sensor decreases and the headlights switch back to their original mode. There might be a question of other sources of light in the road like sign boards, street lights and buildings. But as LDR is used as the source and the placement of the device is highly directional, it is not affected by any other light sources which might be present in the vicinity. Moreover, the light from the vehicle's headlamp is of a distinct nature. The other sources will be located far away from the road and hence their spread angle will be very high.

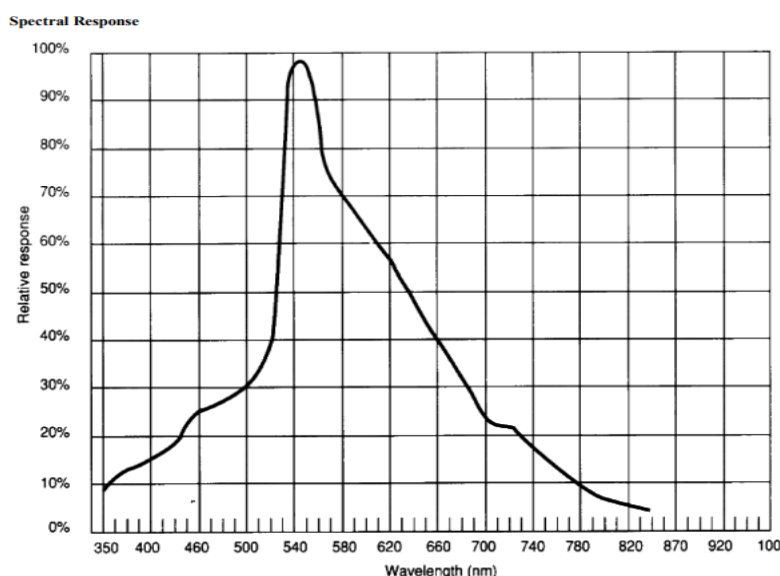


Figure 5.1: Spectral Response

Like the human eye, the relative sensitivity of a photoconductive cell is dependent on the wavelength (color) of the incident light. Each photoconductor material type has its own unique spectral response curve or plot of the relative response of the photocell versus wavelength of light. Mathematically, Spectral Response can be interpreted using the equation below

$$\gamma = \frac{hc}{Eg}$$

Where

h – Planck’s Constant (6.626 x 10⁻³⁴ J/s)

C – Speed of light (3 x 10⁸ m/s)

Eg - 1.12 eV

λ- Wavelength

Phase II: Exiting State of Work with Comparison

K. Okrah.S. [1] Proposed that an automatic headlight dimmer which uses a Light Dependent Resistor (LDR) sensor has been designed to dim the headlight of on-coming vehicles to avoid human eye effects. This automatically switched the high beam into low beam, therefore reducing the glare effect by sensing the light intensity value of approaching vehicle and also eliminated the requirement of manual switching by the driver which was not done at all times. The system device was able to automatically switch the headlight to low beam when it sensed a vehicle approaching from the opposite side using LDR sensor.

Et. al., B.Kalaimathi.,[2] suggested that LDR sensor which acts as a variable resistant that converts the high beam of the upcoming vehicle’s headlight to low beam with the help of Arduino UNO and other components. This system will be a useful in the area of automobile and brings a new trend to ensure the safety of the drivers.

K. Gandhi [3] proposes a prototype of an automatic headlight dimming system, constituting of three major sensors-LDR, rain and fog sensors which provide inputs to Arduino Uno which acts as a microcontroller to provide a control mechanism, that has been developed to toggle the beam from low to high or vice versa for driving scenarios when there is sudden change in climatic conditions or in the visibility (light) in the air.

Farooque Abdullah [4] suggested to improve the safety of the vehicle by using ultrasonic sensors for getting a picture of the obstacles in the path of the vehicle. Another method is suggested to automate the head lamps of the vehicle from high beam to low beam by sensing the intensity of light from opposite vehicle. These techniques increase the comfort and safety of night driving to a large extent.

K.Anusha [5] proposed that Smart Headlight Dimmer is a component in which we can decrease the number of accidents that are causing due to high intensity of light during night times .This helps to reduce the causing of accidents due to Troxler effect. This device helps us to adjust the intensity of the beam of the headlight according to the intensities of the surrounding light.

Murulikrishnan.R.[6] proposed a comparative study of the existing technologies deployed in automatic headlight dimmer systems along with pondering upon the need of automatically controlled systems to switch headlights in automobiles, what are the foundation grounds for headlamp alteration systems, what are the detrimental effects to safety when any driver uses the wrong beam in unsupportable conditions in a vehicle.

Existing traditional headlight systems are not adaptive and rely on manual adjustments or fixed brightness levels, which may not be suitable for varying road conditions. The Automatic Headlight Dimmer system uses IoT technology to dynamically adjust the intensity and direction of the headlights based on real-time data from the camera and light sensor, ensuring optimal visibility at all times. Traditional systems do not consider road curves when adjusting headlights, potentially leading to insufficient illumination in curves and reduced safety.

The integrated model in the proposed system allows for real-time curve detection, enabling automatic adjustment of the headlights to ensure better visibility in curves. Standalone curve detection systems exist that use computer vision algorithms or sensors to detect road curves, but they lack integration with the headlight control mechanism. The proposed system integrates both curve detection and headlight control, providing a comprehensive solution for enhanced driving safety.

Standalone curve detection systems often require separate installations and may not be compatible with existing vehicles, whereas the proposed system can be retrofitted into most vehicles with minimal modifications. By incorporating IoT technology, the proposed system allows for remote access, monitoring, and control, providing added convenience and flexibility.

IV. DISCUSSION AND CONCLUSION

The topic of automatic headlight dimmer and curve road detection using IoT offers several possibilities for further enhancements and advancements. Explore the integration of additional sensors, such as cameras or infrared sensors, to enhance the accuracy of curve road detection and improve the system's responsiveness to road conditions. Utilize machine learning and AI algorithms to analyze sensor data and improve the system's ability to detect curves accurately. This can involve training models using large datasets of road and driving conditions to enhance the system's curve recognition capabilities. Develop an adaptive headlight control system that not only adjusts the brightness based on ambient light conditions but also adapts the beam pattern and direction to provide optimal illumination for different road and driving scenarios. Integrate the automatic headlight dimmer and curve road detection system with other vehicle safety systems, such as collision avoidance systems or lane departure warning systems, to provide a comprehensive safety solution. Expand the system to include intelligent driver assistance features, such as providing steering feedback or guidance during curves, optimizing speed control, and integrating with navigation systems to enhance overall driving safety and convenience. Incorporate connectivity features to enable real-time communication and data sharing between vehicles.

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