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Smart Headlight Dimmer using Raspberry Pi

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Abstract: ***Driving in low-lighting conditions can raise several challenges that may affect your safety at night. Due to darkness, low visibility is the most frequent issue that drivers have at night. It will be difficult to see obstacles, pedestrians and vehicles on the road and another important problem is glare of Oncoming headlights from high intensity beams of xenon or LED headlights of the front facing vehicles. This will lead to temporary blindness for the drivers. In this situation driving the vehicle is a challenging task. It will be difficult to drive with the traditional headlights in such conditions. It poses a serious threat, and many accidents are caused by temporary blindness. According to the Indian statistics, more than 60% of accidents occur during night time and the main reasons behind those accidents is headlights problems. The abrupt brightness experienced by the travellers is known as the Troxler Effect. However, there is an option in every vehicle weather to keep the headlight either high or low when the vehicle is coming from the front side and this is called as upper and dipper system. Some of the drivers do follow this system as the car approaches them at night but a lot of them do not. Due to which it led to the problem of lack of visibility on the road due to constant glare of the headlights. Heavy vehicle's (like trucks and buses) have extremely powerful headlights which produce very high intensity lights that in turn result in fatal accidents. Truck and bus drivers will ignore to reduce the headlight intensity when small vehicles are approaching them. As we analyse the current highway situation, most of the goods and passenger transportation occur during night. In lots of time These vehicles jeopardise the safety of other people. There is no such system available which can automatically high and low beam those headlights of heavy vehicles and even high beams of small vehicles. To resolve this problem, The System should be developed so that when a car or bike approaches another vehicle then there should be automatic change in the upper and dipper mode of the lights and reduce the light intensity. So that accidents due to headlights can be reduced.***

Keywords: (Smart Headlights, OpenCV, Raspberry pi, smart navigation, road safety)

I. INTRODUCTION

Car headlight design has changed over the years, moving from an electronic component of the car to the core of its design and overall functionality. The basic functionality of traditional headlights is to Illuminate the road with constant light as high brightness of the light. Even though flashy headlights typically only operate in the low-beam and high-beam modes. Rather than changing Headlight settings automatically. Intelligent headlights have been developed that emit different intensity's light according to changes in the road ahead and nearby [1]. Auto adaptive headlights (ADB) are another name for smart headlights. The ADB System makes use of a sensor camera and unique headlight designs that modify the light's strength and direction. ADB System makes use of a sensor camera and unique headlight designs that alter the light's brightness and direction. ADB System uses a sensor camera and special Headlight designs that change the brightness and direction of the light. This project smart headlight is developed for providing a better solution for traditional headlights [2]. According to the report of central Transport and road ministry of India, In the year 2021 total 1,66,073 accidents occurred at the night time [3]. To reduce number of accidents at night. This project smart headlight is developed for providing a better solution for traditional headlights. The outline of this paper is to improve headlights of the vehicles.

A. Objective

By dynamically altering the brightness or intensity of the vehicle's headlights based on numerous criteria and driving situations, an automatic headlight dimmer system on a car aims to increase road safety, improve driver comfort, and maximise energy efficiency.
The primary goals include:

1) *Enhanced Visibility:* Auto-dimming headlights are designed to give drivers good visibility possible while minimising glare for other road users. To guarantee that the road ahead is well-illuminated without blinding oncoming traffic or drivers in front of the car, they alter the headlights' intensity.
2) *Safety:* These systems help make driving safer, especially when it is dark outside, it is raining, or the road conditions are difficult. They do this by cutting down on glare and guaranteeing even illumination.

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3) *Regulation Compliance:* Automatic headlight dimmers frequently assist cars in conforming to rules and specifications pertaining to the use of headlights, ensuring that they fulfil safety and visibility criteria.
4) *Integration with Advanced Driver Assistance Systems (ADAS):* These systems are compatible with other ADAS technologies and can operate together to improve vehicle control and road safety.

II. LITERATURE REVIEW

Temporary blindness caused by increased illumination intensity is one of the most major problems for night time transport. While increased headlight intensity improves eye acuity, it has the opposite effect on oncoming vehicles. This issue is exacerbated when both drivers use a greater beam intensity level. Additionally, accidents are more severe at night because of faster speeds brought on by less traffic [4]. The demonstration suggested smart headlights, which will automatically alter their intensity when two cars are close to one another in order to prevent accidents caused by momentary blindness. Compared to 2011, there was a 3.3% rise in traffic accidents in 2012[5].

The National Highway Traffic Safety Administration provided this image. It must be automated since many people disregard the rules governing dimmer headlight beams. Even though the number of vehicles is much smaller than during the day, nighttime accidents nevertheless account for about 33% of all accidents and a larger percentage of fatalities. According to a survey conducted by academics, the potential danger of traffic accidents is doubled when compared to daytime [6]. The Troxler effect occurs in the medical field when intense light falls on the eyes of a motorist, causing blindness of temporary type. It can be also called as 'fading effect'. Study says when light from a source of near about 10,000 lumens falls on human eyes the glare occurs. This glare is caused by overexposure and cones within our eyes. As well as image remains in eyes of human even if source of glare is removed this is called as Troxler effect [7].

Manual switching is the current way for dimming headlights. In the current method, we must manually regulate the switch from high to low beam. It will be always challenging. This concept is designed to eliminate manual complexion while driving and to avoid accidents. The primary components in this case are an LDR sensor, a relay, and an Atmega328. These components are the system's focal point [8]. One of the research articles by G. R. Poornima, V. Harish focuses on the development of a smart energy management system for vehicle headlights. The primary objective of the research was to design and implement a system that automates vehicle headlights while efficiently managing energy consumption [9]. Another study done by S. Ucar, B. Turan, S. C. Ergen addresses possible uses for VLC with dimming support in traffic and intelligent transportation systems [10]. One of the key reasons for the smart headlight dimmer was in order to prevent road accidents and to avoid Troxler's effect at night going further S. Saha, M. A. Mondal and Z. Rehena did research on this and the main goal of their research was to develop and put into use a smart headlight intensity management system for automobiles to counteract Troxler's impacts when driving at night. Their research mainly focused on Troxler's effects mitigation, Intensity control and Driver comfort [11]. There are also a lot of IoT-based automatic headlight dimmer systems and for summarised evaluation these devices research was done by K. Gandhi, K.S. Aulakh where their paper focuses on aspects related to IoT-based automatic headlight dimmer systems such as IoT integration. Sensors and data collection and different evaluation criteria such as energy efficiency, safety, compliance with regulations etc [12].

III. METHODOLOGY

The primary objective of smart headlights is to automatically adjust Headlight's intensity when one vehicle approaches another. This functionality is achieved through a combination of image processing techniques and microcontroller interfacing, specifically using a webcam, servo motors, Raspberry Pi, and Arduino, along with small LEDs serving as the headlight's functionality. The pivotal aspect of this project involves identifying vehicles approaching from the front using the webcam and performing real-time image processing to track these vehicles.

For the implementation of image processing, Python is selected as the programming language. Python is fevered due to its extensive libraries and user-friendly syntax, making it an ideal choice for the task. When it comes to the algorithms for object detection in Python, several options are available, including Haar Cascade, YOLO (You Only Look Once), and object detection using TensorFlow.

In this project, the Haar Cascade algorithm is adopted as the primary method for vehicle detection, because it is a machine learning method for object detection in Python. Its strength lies in its ability to find good products by recognizing certain patterns, and face recognition etc. It has seen applications in many fields such as vehicles and traffic sings detection also.

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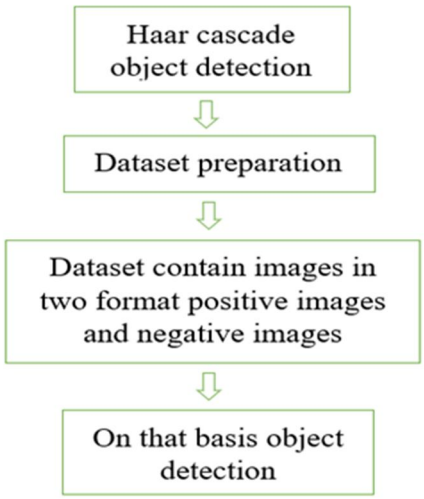


Fig. 1 Haar Cascade algorithm flowchart

As mentioned in the Fig. 1 while training the model with Haar cascade algorithm, it uses either grayscale or colour images. Positive images contain the target object, while negative images exclude it. To ensure effective training, it is crucial to have a substantial number of negative images compared to positive ones, typically with a ratio of positive: negative is at least 1:3. This balanced dataset aids in training the classifier to accurately identify the target object. For this project Positive images depict vehicles.

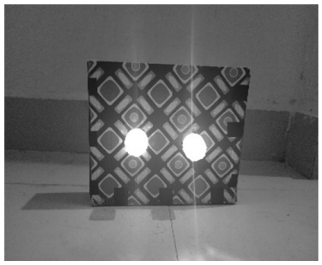


Fig. 2 Model of a car



Fig. 3 Negative image

The model is trained by using the above-mentioned image folders and at the end it will be generated .xml file as the model for the further uses. After testing model for headlight detection, distance between detected object and car is calculated with the help of

$$Y = mX + C \ldots (I)$$

As in the Haar cascade bounding box will be kept around the detected object, and as the width of that box grows or shrinks as that object goes near or far from the camera with the help of this functionality distance of that object in centimetres can be calculated. First object has been kept at the known distance that is 30 or 40 centimetres from the camera and width of the bounding box has been calculated and those values has kept in the equation

$$Y = mX + C$$

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Whereas Y is the known distance between camera and object, x is the width of the bounding box, similarly by putting object near to the camera and at known distance i.e. at 15 centimetres and calculate the width for one more time and put that in the same equation now by solving those two equations .Value of **m** and **c** can be calculated and can be put in the actual equation that is again y=mx+c but this time m ,c are the calculated values and x will be the width of the bounding box so by putting all that y can be calculated and use as a actual distance.

Y1=M*(X1)+C —>equation(1)
Y2=M*(X2)+C —>equation(2)
When distance is 15cm width(p2-p1) is 82 pixels
When distance is 30cm width(p2-p1) is 68 pixels

Distance	Width	Equation
15cm	82	15=82*(M)+C
30cm	68	30=68*(M)+C

Fig.4 distance calculations

So, the calculated values of M and C are M=-1.07, C=102.857

IV. PROJECT ARCHITECTURE

Overall architecture is based on the Raspberry Pi 3B+ connection to the Arduino Uno using SPI protocol for the information transfer. This information contains detected object distance using a camera module mounted on the car. Using that information, the Arduino will be able to make decisions for the movement of the servo motors and dimming the lights of the car, servo motors, LEDs are Connected with the Arduino UNO. The main concept of the project is to identify the headlights of the approaching cars in the dark and to dim the headlights of the other car (car which has detected the headlights) and once both the cars pass away again to blow the lights at the full extent. This system will be fit in both the cars so that none of the drivers of the cars will face the difficulty while driving in the night. The overview of the work can be taken from the figure no 5.

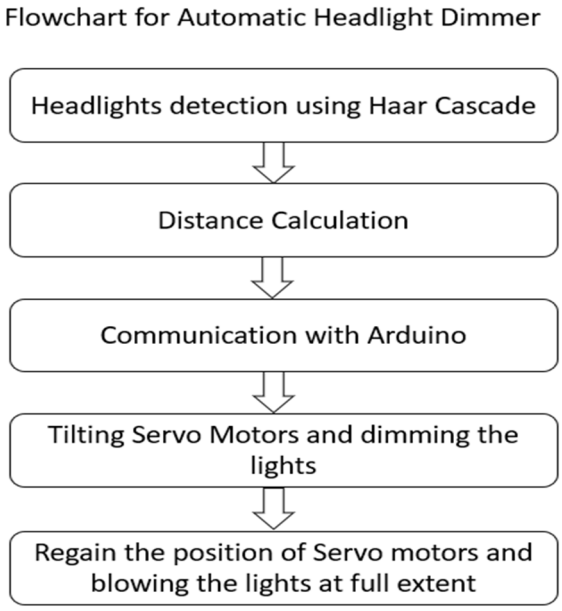


Fig.5 project flow

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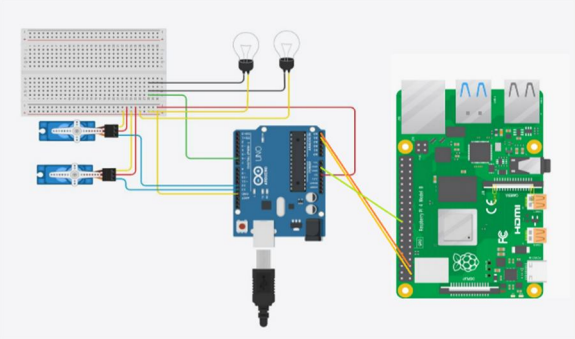


Fig. 6 Circuit diagram

V. TOOLS AND TECHNOLOGIES

A. *Raspberry Pi 3 B+*



Fig. 7 Raspberry pi 3B+

There are numerous studies being done today on object detection using Raspberry Pi and image processing. Image processing is typically used to speed up object tracking, categorise items, and make sure that all things in the environment are adequately detected [17]. Processor of Raspberry pi 3B+ is 1.4GHz and it is 64-bit quad-core, as well as model 3B+ has 40 GPIO pins. In order to use Raspberry pi one should have a Raspberry pi operating system

B. *Raspberry Pi OS*

A Debian Linux-based Unix-like operating system for the Raspberry Pi line of small single-board computers.

C. *OpenCV*

OpenCV is one of the libraries in the python several tasks such as machine learning image processing etc. can be done with the help of OpenCV and python. While with the help of computer vision images and videos can be understood as well as can be manipulated in order to retrieve the data from them.

D. *Arduino UNO*



Fig. 8 (Arduino UNO)

Arduino is the most commonly used microcontroller board which has ATmega328P. Specifications of Arduino includes fourteen digital pins which acts as a input or output pins out of 14 six are pulse width modulation pins Arduino also contains USB port as well as power jack and has resonator of 16MHz. It also has feature of reset button and has header named ICSP.

E. *Arduino IDE*

This is the integrated development environment where several programs related to Arduino can be written and communication can be established with Arduino as well.

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F. WebCamera



Fig. 9(Webcam (Logitech webcam c70))

Logitech c70 is used as a webcam for the system in order to capture the video of the water bodies.it has HD 720p/30fps Resolution FPS and has 55° Diagonal Field of View and 1.5 m of Cable Length

VI. FUTURE SCOPE

As in the above paper method followed for image processing is nothing but Haar cascade based as Haar cascade determines only one type of object at a time more advanced algorithms like yolo and TensorFlow can be used for the image processing. As well as more accurate distance measurement can also be done in future. As if multiple cars are at the same distance from the camera, the system may not be able to detect all of them, as it is designed to detect only one object at a time so more advanced algorithms can be used. As in typical upper dipper system 2 lights are used for achieving high and low beam of light and discussed algorithm only uses one and ability of PWM signal of Arduino for lowering the light ,2 lights can be use in future with the help of relays. More accurate dipping of the servo motors can also be done in future. As raspberry pi B3 model is used as a primary microcontroller in the work it is little bit slow than today's laptops and computers so this microcontroller can be replaced by the more powerful microcontrollers. As well as Arduino can also be replaced by the advance microcontrollers which has more speed and processing power than Arduino. As to operate this system microcontrollers which has more speed and processing power than Arduino. As to operate this system raspberry pi must be connected to the WIFI of home router or the mobile sometimes it needs more speed of the internet for the processing so this system can also be replaced by wired system or some other systems.

VII. CONCLUSION

The above demonstration shows the use of OpenCV to detect the approaching vehicle in the night time thus resulting in the activation of the servo motors and also the reducing the intensity of lights this demonstration doesn’t depend on sensors such as LDR that are commonly used to for detecting light intensity but a camera module to detect the approaching car thus making it more reliable solution for fighting the temporary state of blindness called the Troxler effect, LDR sensors are unreliable because the variation in resistance value has a delay, which differs depending on whether it travels from dark to illuminated or illuminated to dark. This restricts their applicability in applications where the light signal varies frequently.

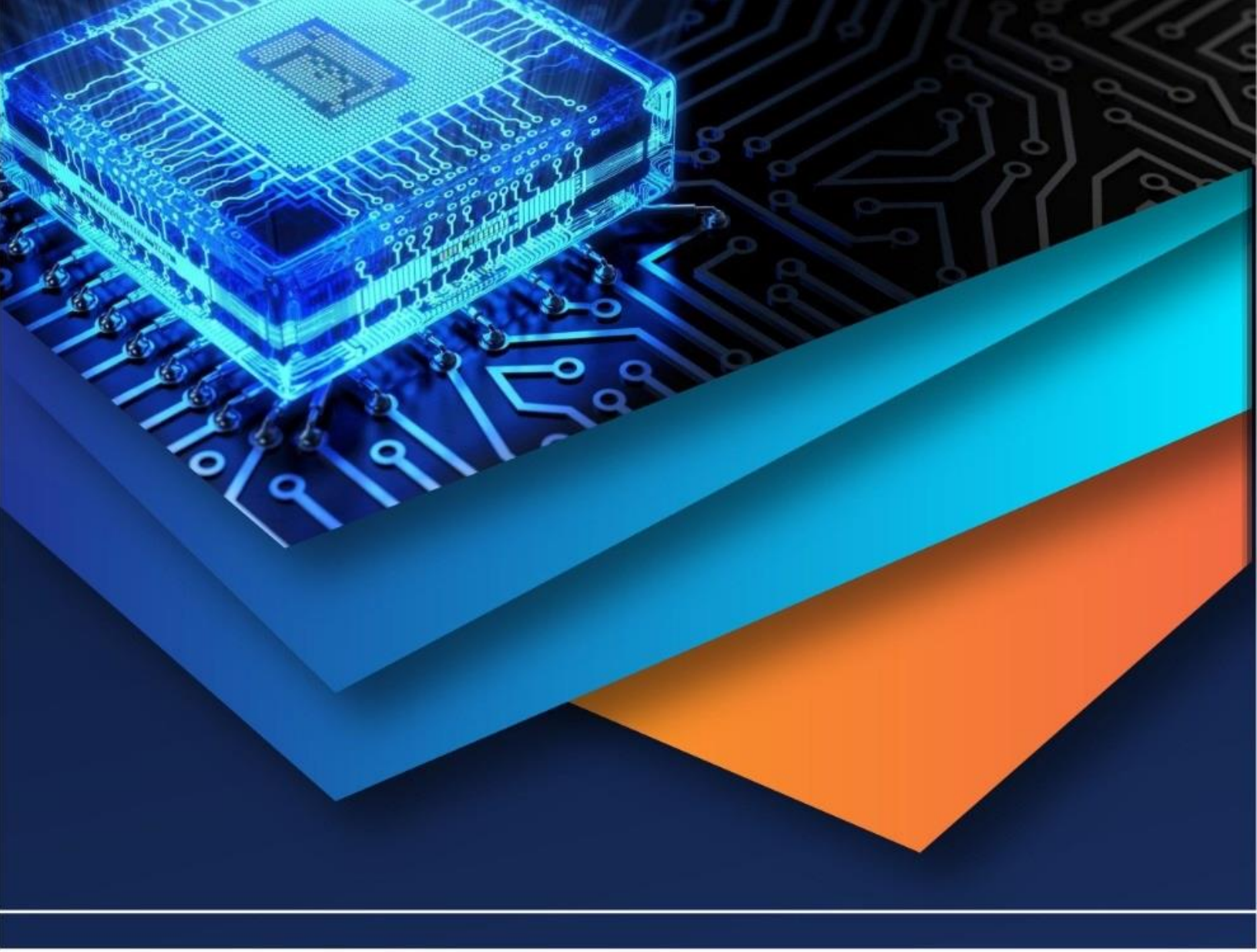
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