Smart LED Headlights using IP

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Abstract— In the current date, the number of vehicles on the road has increased significantly. This has resulted in increased accidents, particularly during night-time. During night time, the glare from oncoming vehicles and from road during rainy seasons is the cause for many accidents. Hence our project, Multibeam LED Headlamps using Image Processing, aims to reduce the number of accidents by automatically adjusting the brightness of a multi-beam LED headlamp based on detection of an oncoming vehicle using Image Processing (IP). Detection of oncoming vehicle during night-time is the most important part of our project. During night-time, the vehicle is not clearly defined i.e. to a camera the vehicle is not distinguishable from surroundings easily. Hence the usual methods of vehicle detection cannot be applied such as Sobel edge detection. So a new method has to be used for detecting vehicles at night. In this method, the vehicles tail-lights/headlights are used for identification. A camera will capture images at night from inside the car. As the lights are significantly bright than other elements in the surrounding, they are easily distinguishable. Now, the problem is of other light sources such as lamp-posts. Therefore a photodiode is used to sense the incoming light of the car. Further, the image is converted to grayscale, thus reducing computation complexity even more as color images take time to process. This will improve results in real-time traffic situations. Also the software will simultaneously search for a different vehicle in the image when the current vehicle is being processed. All this computation is done using MATLAB software running on a laptop computer. Now for control of headlights, the MATLAB software will be interfaced with a microcontroller such as ATMega2560 to control the dimming of headlights.

Keywords— Image Processing, Background Subtraction, Structuring Element, Blob Analysis.

I. INTRODUCTION

Nowadays there has been a tremendous increase in the number of accidents during night time due to the excessive oncoming headlight intensity. Since our ability to perceive and judge distance is severely impaired at night-the human eye requires light to see-night driving is the top cause of car accidents. Despite 60 percent less traffic on the roads, more than 40 percent of fatal car accidents occur at night.

Even though at night, there are variety of man-made lights that will help drivers safely navigate the roads. Our eyes will adjust to the lower levels of light (pupil dilate in darkness and constrict in brightness), but they have difficulty functioning properly when switching from bright to dark or vice versa. These cause a glare in the oncoming driver's eyes, creating Troxler's effect. Hence this paper aims to demonstrate a way to build a smart headlight intensity controller which will detect the vehicle/object on the road and using Image Processing will reduce the intensity of oncoming headlights on the driver. The detection of the object can be done with the help of various object detection algorithms using Image Processing.

Detecting objects like pedestrians in unconstrained images or videos, tracking them over time, and recognizing their actions are challenging tasks due to high intra-class variations in shape, appearance, scale, viewpoint, and pose, but also due to occlusions, illumination changes, and background clutter. Nevertheless, there has been considerable progress over the last years, particularly in the field of object detection in static images. Thus this paper will now discuss the different methods of object detection presented over the past few years.

II. LITERATURE REVIEW

The Multibeam LED Headlights© were first introduced by Mercedes-Benz AG in 2016 on the CLS Coupe. They use an active matrix of LED's to control individual LED beams for

increased lighting accuracy. But that is expensive and limited to Mercedes vehicles due to patent issues. To implement the same technology at lower cost and with minimum components possible, we researched various papers on Vehicle/Object Detection.

[1] Ms. Bhagyashri Makwana et al. presented a paper on "**Moving Vehicle Detection and Speed Measurement in Video Sequence**" in *International Journal of Engineering Research & Technology (IJERT)*, ISSN: 2278-0181, Vol. 2 Issue 10, October – 2013. They have discussed a simple method for extracting objects from an image. A photo of a background without object is compared with a current photo which has an object in it. Hence background subtraction is used to extract objects. But before this, the captured image is first filtered to remove inherent noise in the frame. And while this technique is simple, it has lot of disadvantages. This method will also separate other objects like road signs, pedestrians etc. from the frame along with the vehicle i.e. object of interest.

[2] Zhiming Qian et al. presented a paper on "**Video-based multiclass vehicle detection and tracking**" in *International Journal of Computer Science Issues*, Vol. 10, Issue 1, No 3, January 2013. In this, the features are grouped by analysing the motion of the vehicle between two consecutive frames. This method has less computational complexity and has several advantages. But if the features are not grouped correctly, the vehicle may not be detected correctly. [2] also gives an overview of vehicle tracking methods such as region based method, contour based method, model based method and feature based method. This is an extension of the above feature based detection.

In region based tracking, consecutive frames are acquired and vehicle is extracted each time. The region of object is identified and its location is calculated. After some consecutive images, we obtain a train of regions which can be used to track the movement of object. In model based tracking, a pre-generated model of a vehicle is compared with the captured object and vehicle is identified. In active contour based tracking, the contours i.e. the curves of the surface of object are pre-determined and compared with captured object. This method reduces computational complexity but has one major disadvantage; contours for each vehicle have to be computed previously which increases time of development.

[3] Siddhartha A. Meshram, et al. presented a paper on "**Vehicle Detection and Tracking Techniques Used in Moving Vehicles**" *in IJISET - International Journal of Innovative Science, Engineering & Technology*, Vol. 2 Issue 7, July 2015. In this the motion segmentation method is defined similar to region based tracking as above. Although in this method, whenever a different object is encountered, a different class is created for that object. This involves additional computation which increases complexity.

[4] Prof. V. B. Sutar, et al. presented a paper on "**Night Time Vehicle Detection and Classification Using Support Vector Machine**" in *IOSR Journal of VLSI and Signal Processing (IOSR-JVSP)*. In that, they have discussed another novel method to detect vehicles in night-time. They have used the headlights/taillights of vehicle for identification. Since the lights are significantly brighter than other light sources and are symmetrical, they can be easily used to identify a vehicle. They have used canny edge detection, Hough transform, and major straight line extraction for this purpose. But this has a major disadvantage. The glare from oncoming vehicles can seriously degrade the performance of the system.

[5] Padmavathi.S, et al. presented a paper on "**Night Time Vehicle Detection for Real Time Traffic Monitoring Systems: A Review**" in *Int.J.Computer Technology & Applications*, Vol 5. It also discusses the same strategy as above but they have one important advantage; they use histogram equalisation to counter the effect of glare of headlights.

[6] Devashree Chilla, et al. presented a paper on "**Headlight Intensity Control Methods**" in *IJIRCCE, International Journal of Innovative Research in Computer and Communication Engineering*, Vol. 4, Issue 2, February 2016. In this paper, they have emphasized on various methods and techniques that can prove beneficial in monitoring the headlight intensity of vehicles. The light intensity parameter should be within the human vision comfort zone so as to avoid blind spot to the driver at night and to be less prone to accidents usually occurring due to excess glare of headlamps. If such methods are implemented by manufacturers the device will automatically switch to low beam from high beam as per the headlight intensity of approaching vehicle.

[7] Victor Nutt, et al. presented a paper on **"Headlight Intensity Controller Design using Wireless Sensors"** in *ICNICT 2012, Special Issue of International Journal of Computer Applications on Issues and Challenges in Networking, Intelligence and Computing Technologies*, November 2012. In this paper, WSN based controller is designed to modify the intensity of headlight of a vehicle to such a level that during vehicle cross over blind spot situation does not arise. This is achieved in real time while providing better vision sharpness for the driver.

[8] Muralikrishnan.R, et al. presented a paper on **"Automatic Headlight Dimmer A Prototype for Vehicles"** in *IJRET, International Journal of Research in Engineering and Technology*. This paper conveys that, due to the sudden exposure of our eyes to a very bright light; the bright headlights of vehicles in this case causes a temporary

blindness called the Troxler effect. Hence they have mentioned the idea for the design and development of a prototype circuit called the automatic headlight dimmer. It allows the driver to use high beam light when required. But it automatically switches the headlight to low beam when it senses a vehicle approaching from the opposite side. Thus the implementation of this device in every vehicle in future will not only avoid accidents but also provide a safe and a comfortable driving.

[9] Ramya Dhawle, et al. presented a paper on **"Automatic Headlight Beam Intensity Switcher"** in *IJRET, International Journal of Research in Engineering and Technology*. In this paper, the working product they implemented achieve the aim of switching the beam from high to low or vice-versa. This system not only assists the driver but also protects him from the temporary blindness due to the opposing headlight glare. Thus, the product provides safety to the driver especially during the night time.

[10] Pulkit Khandelwal, et al. presented a paper on **"Detection of Features to Track Objects and Segmentation using GrabCut for Application in Marker-less Augmented Reality"** in *Second International Symposium on Computer Vision and the Internet (VisionNet`15)*. This paper dealt with the development of an augmented reality system and has led to new research and advancements in this field with applications in gaming, medical sciences, video and sound production. This system was able to detect, track and segment out an object of interest in real time. They then used Support Vector Machine to recognize real world objects and classify them. They also used Homography techniques to determine the pose matrix to control the rotation, scaling and translation of the virtual object. The augmented reality application developed was based on the marker less approach. The adapted algorithm they put forth, worked efficiently, accurately and reliably, and it also has scope for further improvement by the utilization of better computationally efficient descriptors and interest point in detectors such as STIP.

[11] Musab Coúkun, et al. presented a paper on **"Implementation of Tracking of a Moving Object Based on Camshift Approach with a UAV"** in *9th International Conference Interdisciplinary in Engineering, INTER-ENG 2015*, 8-9 October 2015. In this paper, just a test of tracking a moving object was successfully fulfilled in the laboratory. A traditional Camshift approach was employed to track the object. To solve this problem and improve the tracking system, a robust approach is implemented.

[12] Filip Šuligoj , et al. presented a paper on **"Object Tracking with a Multiagent Robot System and a Stereo Vision Camera"** in *24th DAAAM International Symposium on Intelligent Manufacturing and Automation*, 2013. This paper utilises sensors, developed tracking markers and software in order to achieve greater robot autonomy when working in unstructured workspaces. In this the robot system based on stereo vision guidance through 3-D space has been proven to work in laboratory environment. This system has been tested with object tracking and pick and place applications. Here, two feature based marker detection approaches have been compared in terms of reliability and precision.

[13] Jianqiang Wang, et al. presented an article on **"A Region Tracking-Based Vehicle Detection Algorithm in Nighttime Traffic Scenes"** on 2 December 2013. In this paper, they have explained the problem of detecting the preceding vehicles in nighttime traffic scenes via the image processing technique. Based on the brightness of the taillights at nighttime, they use the features, e.g., length-width ratio, intensity, shape, color, symmetry, to identify the taillight pairs at night. To improve the detection accuracy, they have proposed a region tracking-based vehicle detection algorithm to detect the pairs of the taillights. Therefore, the detection time is reduced and the false pairings between bright spots in the taillights and the bright spots out of the taillights are eliminated.

[14] Dhruv Gupta, et al. presented a paper on **"Driver Friendly Headlight Controller for Driving in Developing Countries"**. In this paper, an attempt is made to design Mamdani FIS based on incoming light intensity for the automated headlight control. This system is designed to avoid blind spot, during night driving on highway. The FIS has been designed, implemented, and tested based on light intensity as the only parameter bounded by human visual comfort zone. The expected behavior of the system matches general intuition due to the incorporation of the human visual system into the design. Moreover, the system does not require sophisticated hardware or complex learning strategies, and it provides robust and low cost solution. The system can also be installed and operated in a standalone mode. Thus it is a well suited solution to intelligent headlight control for night driving in the developing countries.

[15] Darko Jurić wrote a paper titled "**On-road Night-time Vehicle Light Detection and Tracking Methods Overview**". It describes almost the same technique we are going to use for our project. This combinely describes all the techniques discussed above to get the final result. We will be following this paper as our base for future work. It describes in detail techniques such as thresholding, LoG (Laplacian of Gaussian) approximation, particle filtering for detection and pairing of vehicle lights. It also suggests the use of fuzzy logic for classification of lights as they do not have crisp values.

III.   METHODOLOGY

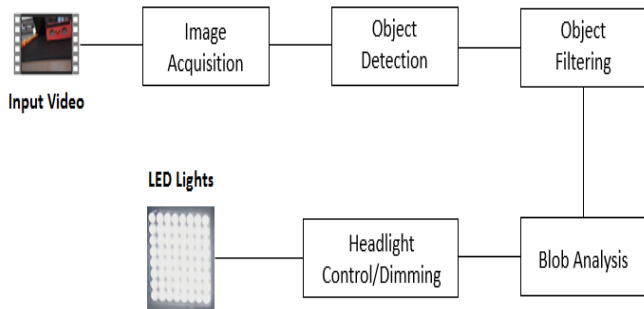In this section, we will discuss the overall implementation of the topic, divided into number of sub-sections.

Fig. 1 – Block Diagram

2.1 Image Acquisition

There are various methods to acquire images. A live camera feed can be used to acquire images. Or a video file, preloaded into the system can be used for image acquisition. Now since this topic uses MATLAB for implementation, we use functions such as *vision.VideoFileReader()* and *videoinput()* to acquire images from video file & camera respectively. Once video is loaded, we start extracting the frames using *step()* function. The MATLAB command is *var=step(videovar).*

Fig. 2 – Original Image

2.2 Object Detection

Now after successful extraction of frames, we try to find objects in it. An object, in a frame, is a closed group of pixels whose values are very different or they abruptly change in the frame. Objects are generally located in the foreground whereas the other part of frame is known as background. For this paper we will study the method of **Background Subtraction,** which is very easy to implement and produces acceptable results.

In **Background Subtraction**, the previous frame is subtracted from the current frame to subtract the background i.e. to remove the background. This is possible even in real-time videos due to one simple fact, high degree of correlation between successive frames. After successful subtraction, we get a black & white image where white pixels represent object & black pixels are foreground. This B&W image is very crucial as it will decide the type of structuring element to be used for object filtering and classification. If the resulting image from subtraction does not have any white pixels, it means that there is no object and vice versa.

Fig. 3 – Background Subtracted Image

2.3 Object Filtering

Now we have a B&W image which has both objects and unnecessary noise. So to remove this noise and smoothen the object boundaries, we filter the image using structuring elements. We choose the structuring element of such size that it will remove the noise but at the same time enhance the object. Now as we are detecting vehicles which generally have rectangular shape, we use 2 structuring elements, one square to remove small noise and one rectangle, to remove larger noise and enhance the required object. The *strel()* function is used in MATLAB to generate STRucturing ELement. It is applied on the image using the *imopen()* command. After filtering, we get the final filtered image which contains object and a small number of noise which are large in size to pass through filtering.

Fig. 4 – Filtered Image

2.4 Blob Analysis

Now upto this point, the user had no way to determine whether there was any object or not, unless the program is debugged. So to automate this decision making, we use Blob Analysis. As the filtered image denotes object as white regions of pixels, blob analysis is a useful tool to automatically detect presence of objects. The function used is *vision.BlobAnalysis()*. Now here, there could be one or more objects. So to keep count of objects, we store the number of connected regions in a variable called '*bbox*', which stands for *Bounding Box*. It is a *nx1* matrix, where '*n*' is the number of regions. Thus we can now determine the presence of objects and give commands to Arduino to adjust headlights accordingly.
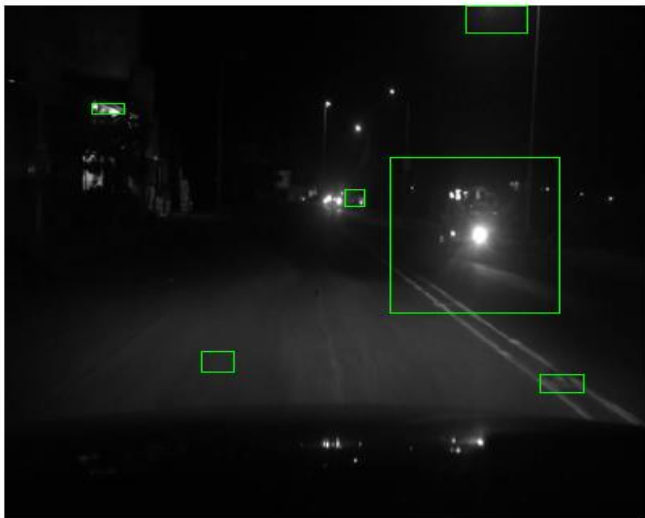
frame1 <400x400 single>

	266	267	268	269	270	271
133	0.0696	0.0678	0.0731	0.0773	0.0752	0.0761
134	0.0702	0.0699	0.0734	0.0771	0.0759	0.0779
135	0.0706	0.0703	0.0710	0.0726	0.0753	0.0792
136	0.0704	0.0702	0.0723	0.0764	0.0807	0.0827
137	0.0709	0.0700	0.0728	0.0801	0.0832	0.0863
138	0.0724	0.0699	0.0749	0.0801	0.0836	0.0867
139	0.0738	0.0728	0.0771	0.0800	0.0840	0.0873
140	0.0744	0.0748	0.0791	0.0826	0.0856	0.0874
141	0.0785	0.0794	0.0802	0.0842	0.0875	0.0899
142	0.0795	0.0825	0.0852	0.0887	0.0919	0.0922
143	0.0802	0.0841	0.0878	0.0911	0.0965	0.0983
144	0.0792	0.0829	0.0883	0.0937	0.1003	0.1007
145	0.0810	0.0865	0.0911	0.0958	0.1041	0.1035

Fig. 6 – Pixel values of Input

Fig. 5 – Final Image

foreground <400x400 logical>

	266	267	268	269	270	271
133	0	0	0	0	0	0
134	0	0	0	0	0	0
135	0	0	0	0	0	0
136	0	0	0	0	0	0
137	0	0	0	0	0	1
138	0	0	0	0	0	1
139	0	0	0	0	0	1
140	0	0	1	1	1	1
141	0	1	1	1	1	1
142	1	1	1	1	1	1
143	1	1	1	1	1	1
144	1	1	1	1	1	1
145	1	1	1	1	1	1

Fig. 7 – Pixel Values after Background Subtraction

2.5 Headlight Control/Dimming

Now that we have the count of objects, the decision to dim the lights or not can be made. For this, the value of the variable '*bbox*' is checked. If it is 1 or greater, the headlights are dimmed. If the size is 0, the lights are kept as it is. Thus we have automatic control over the headlights depending on the traffic conditions.

Hence to reduce these false detections, image opening is done using structuring elements. These are used to filter the image so that closely grouped objects are made distinct and kept, everything else is discarded. This filtered image is as shown in the Fig. 4.

Then *blobAnalysis()* function is used to determine the location and count of the objects. This location is then stored as the columns of the vector `bbox` as shown in Fig. 8. Once done, the size of the bbox vector is checked. If it is greater than 0 i.e. number of rows are greater then 1, a green rectangle is drawn around it using *insertShape()* function. The color of the rectangle can be anything, but green was chosen for its easy visibility and for the fact that human eye responds more for green color than any other color.

IV. RESULTS

Initially the first frame is obtained. Some frames later, in one particular frame, as shown in Fig. 2, we can visually distinguish between the car and the background.

Now background subtraction is applied to this frame and obtain the image as shown in Fig. 3. But as seen, apart from the car, a lot of other differences are also visible. The pixel values for input and background subtracted frames from the border of the largest white area are shown in Fig. 6 and Fig. 7 respectively. It can be seen that, the brighter pixels (those who have higher values) in Fig. 6 are converted to 1 in Fig. 7 i.e. represented as 1 and others are zero. The threshold can be identified to be 0.0750 from the images.

bbox <2x4 int32>

	1	2	3	4	5
1	240	119	106	122	
2	287	1	39	22	
3					
4					

Fig. 8 – Values stored in bbox variable

Finally the vehicle is highlighted as shown in Fig. 5. This is achieved using the *insertShape()* function. The co-ordinates are taken from the *bbox* variable as shown in Fig. 8. So until now, detection of oncoming vehicle is done. But as it can be

seen from Fig. 5, there are some false positives observed. Hence to take them out of consideration for headlight control, an external input is needed, one that certainly confirms that the object is a vehicle. Thus the headlights/taillights of the vehicle will be used as it is the most distinguishing feature of any vehicle at night.

Now the output of photodiode is observed. It gives out logic 1 (5V) when it senses incoming light. The threshold is variable, but it has been set to 3.5V for this project. There are 64 LEDs in each headlight placed on either sides of the vehicle. Then upon receiving logic 1 the lower part of the LEDs i.e. the lower 40 LEDs from each headlight section i.e. LED Matrix are turned off as shown in Fig. 9. However, if the size of *bbox* is 0, the LEDs will remain active as there is no object.
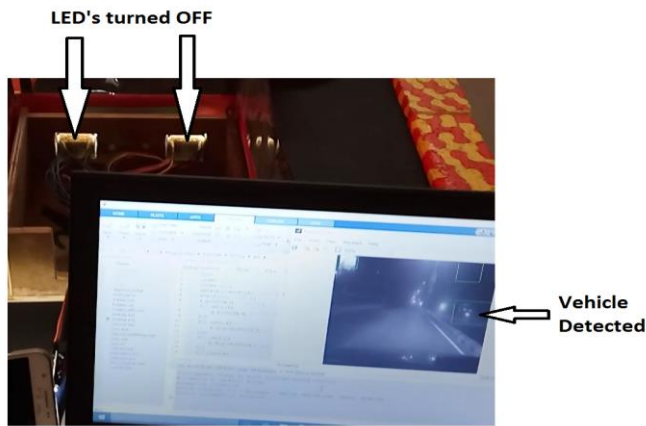

Fig. 9 – Output (No Vehicle)

If the size of *bbox* is 0 or the photodiode is giving logic 0 at output, the lights are kept as it is in full beam mode i.e. all 128 LEDs will be ON as shown in Fig. 10. Now here the word 'or' is used. That is because for the headlights to switch i.e. change state, both the conditions must be satisfied. If they are not satisfied, we cannot be entirely sure whether the detected object is a vehicle or not and thus, if the lights turn off for the wrong object, the possibility of an accident is greatly increased. Hence as it can be seen in Fig. 10, some objects are being detected, but since they are not vehicles, all the LEDs are ON.
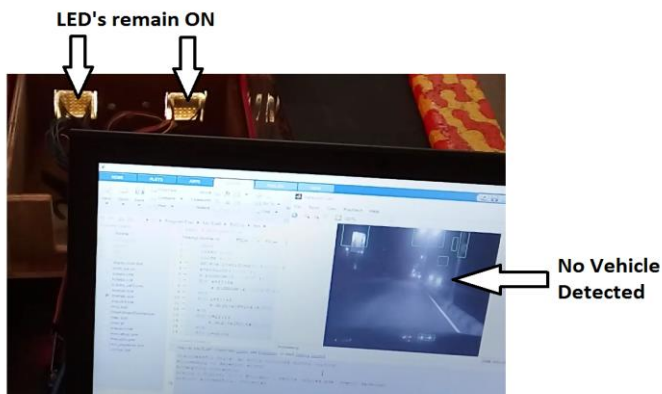

Fig. 10 – Output (Vehicle Detected)

V. CONCLUSION

In this paper, we have successfully discussed the methods for implementing **Smart LED Headlights** using Image Processing (IP). The method discussed provides us with a simple yet effective result which can be used to prevent majority of accidents. However, this method is crude in comparison with some other techniques such as Haar Classifier, Neural Networks, etc. Also the lighting conditions call for an adjustment in the parameters for background subtraction. Thus photodiodes need to be installed to judge lighting conditions. Thus we can conclude that while the method discussed is simple yet effective, there are a lot of improvements to be made if this system is to be introduced in automobiles globally.

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