Research Article

Design & Implementation of Smart Headlamps, Overtaking Assistance for Automobiles using MATLAB

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Abstract: A large number of accidents occur due to human errors especially during night driving because of temporary blindness caused by the headlights of the oncoming traffic. This can be drastically reduced with the adoption of a Smart Headlamp and overtaking kit, which notifies the driver to judge and make a perfect overtake based on the oncoming traffic and also will suggest safe overtakes. The system will Auto- dim one side of the headlight to avoid high beam blindness for oncoming traffic, this system also recognizes the vehicle in front and decreases the beam to low if the vehicle is in certain specified proximity. The use of cameras to detect objects, vehicles, animals, humans is really helpful as compared to sensors. The accuracy of image data is much more than that of sensor data. With the combination of image data and sensor data the system can operate with greater efficiency.

Keywords: Adaptive Driving Beams, Troxler's Effect, Back- ground subtraction, Farneback algorithm

1. Introduction

Of the total accident nearly 40% of the fatal accidents occurs at night. In India due to the blindness of the eyes caused due to flash of bright light nearly 18.9% of the accident occurs. Due to the overtaking nearly 82% of the accident occurs. There is a need to design the smart headlamps and overtaking assistant system to minimize the accidents. MATLAB R2018 is used to simulate the smart head lamps and the overtaking system is verified before the hardware implementation. System will assist the driver in making the decision to overtake the vehicle ahead.

Advanced front lighting system [1] developed as dynamic lighting system that allows the illumination of road according to speed and steering angle. Steering angle sensors were used to monitor the position of the steering wheel to illuminate the road according to curvature. Mercedes Benz came up with the 'Active Curve Illumination' technique to monitor the oncoming traffic and adjusts the high beams appropriately. This system uses high beam xenon lights, dimming one of the lights which directly falls on the windscreen of the oncoming vehicle. But this system is very expensive, these systems cannot be adopted on smaller and low end vehicles. Overtaking Assistance based on the joint-beaconing and Real time video transmission [2], requires high speed network which is practically not available at all locations. Adaptive front light systems which uses ultrasonic sensors to dim or dip the lights are also developed. Hence there is a need for cost effective and accurate system for overtaking and headlamp assistance which will reduce the number of accidents caused by Troxler's effect and improper driver judgement.

There is also a necessity of smart headlamps to assist both the driver and the oncoming vehicles to illuminate the road optimally at the curves at night. The Smart headlamp and overtaking system uses a set of cameras at the front and back of windshields to retrieve image data for analysis purposes. The image data will then be processed using a controller which will later detect and identify various objects, and classify them later on based on the set of programs fed to the system. The processed image information will have certain actions which need to be performed by the hardware devices interlinked to this system. The output from the controller is provided either to the headlamp assembly system or to the overtaking assistance indicator based on image data and action to be performed after being processed. The system uses MATLAB as a software platform to retrieve information and process the codes, and a custom hardware platform is built with a neatly designed circuit diagram and orderly and uncluttered arrangement of wires is done in order to maintain quality and ease of accessibility.

2.Literature Review

The Overtaking assistance and smart headlamps have a few alternatives which would be usually pointed out, when this project is proposed. The key points from these references have been taken into account and the flaws existing in the current systems have been negotiated with, by the use of alternative efficient methods to overcome the differences in the expected outcomes of the references. The overtaking assistance with the combination of smart headlamps would be a very safe method to reduce the number of road accidents and increase the vehicle safety and aid the driver when necessary.

Time to Contact (TTC) is a procedure to decide when it is safe to surpass the other vehicle [3]. Drivers must gauge the TTC of the approaching vehicle. Data of the approaching vehicle's TTC is accessible in the optical extension design, however it is below the threshold during rapid overtaking, which require an enormous distance to pass. This implementation finds that the drivers depend on the apparent separation and velocity and that their decision to overtake would be affected by approaching vehicle size. It is likewise discovered that drivers may misinterpret their decision to overtake regards to motorcycles because of their sizes adding to mishaps.

A driving system simulation was utilized to inspect in the case of overtaking decisions which are affected by the size of an approaching vehicle and by whether a driver effectively leads the surpassing move or latently judges whether the decision is protected or not. The aftereffects of this exploration have suggestions for traffic, well being and the likely job of driver- help technologies. The Adaptive headlamps framework [4] centers around the lighting edge control of low-beams of the headlamps which its light tracks moved on a level plane. The controller in headlamps depends on the image processing algorithms used in the camera system mounted on the vehicle. This framework comprises of compact Raspberry Pi, Arduino micro-controller, and two stepper-motors for each of the two headlamps. The framework was executed on the headlamps of Toyota Avanza vehicle. This framework could distinguish most sorts of vehicles ahead. It could diminish a 'glare' impact and increment the driver sight dependent on overview taken from the driver and the driver of the opposite vehicle. The framework despite everything couldn't distinguish the contrary vehicle with high power of light from braking lights, just as the light from the front lights of the opposite vehicle.

Object Detection System for Vehicles is about the utilization of edge recognition strategy to distinguish the on-coming vehicles. The image detecting framework for vehicles incorporates image sensor and a controller. The sensor catches a picture of the scene of the vehicle. The controller gets the image which involves the picture information collection illustrative of the outside scene. The control may apply an edge identification calculation to a reduced data set of image. The reduced data set of the image is an indication to the target zone. The control might be operable to process the diminished collected image data set to detect if an object is found in the target area. The imaging framework might be related with a side object identification system, lane change assistance framework, a path take-off cautioning system or potentially the like. New technologies related to safety must also meet the comfort and aesthetic. The smart headlamp framework presently used is a mix of comfort and safety. The top performing headlamps of future will be the replacements of the present standards. By utilizing the sensor data accessible in the vehicle, the light dispersion will be adjusted to various driving circumstances and create an advanced light conveyance system to enable safe driving. Estimations rating glare impacts during bend street driving for various headlamp control and calculations are done. Examinations show that adaptive bend lights can lessen glare by utilizing appropriate parameters to bend the headlights. Adaptive Driving Beam (ADB) is a kind of versatile front-lighting framework that consequently empowers upper beams of the headlamps and adjusts their beams to make a concealed region around the approaching and preceding vehicles to improve for the driver without causing inconvenience, interruption, or glare to other street clients.

Frameworks that assist Overtaking using Vehicular Adhoc-NETworks (), depend on either the current video transmission or by using Beacons that could act as messages. In the primary case, a video stream which is compressed and communicated to the vehicles driving behind it, where it is shown to the driver. In the subsequent case, beacons that incorporate position, speed, and heading are by all the vehicles in the zone to guarantee location of approaching traffic. This is a steerable headlight that is designed by adjusting an ordinary static headlamp [14] that is less expensive while is highly reliable. At the point when a path change of the vehicle is predicted by methods for a channel which utilizes data of the vehicle kinematics and the street shape [15], the communication system reports this alongside the route information (navigation path) of the vehicle by means of the network. Those vehicles in a territory of probe which approaches a similar area and drive the opposite way are liable to concentrate by the Interpreter subsystem. The directions of the two vehicles are anticipated by their kinematics and the data of the shape of the road that is stored in the computerized map, and a pointer of the evaluated danger of the move is given dependent on it. The shift from high-shaft to low-shaft or vice-versa and turning on and off the fog light as indicated by visibility. To make it cost effective, a PIC micro-controller technology along with a Light Sensor is used. As indicated different studies major accidents happen during overtaking which is roughly around half during 2014 [16] of the accidents happening and second highest while changing lanes, motorways and expressways within the city limits.

From the survey conducted for this project, it was understood that there was dire need for a cost effective system that can aid the driver in making decisions while overtaking vehicles. From the statistics of the increasing number of accidents occurring at night, it was necessary to come up with a system that can avoid temporary blindness caused by these high beam lights and also illuminate the road as per the requirements of the driver. It is essential in today's world to standardize such driver aids which can help both in overtaking situations and to aid the driver to see the road properly especially during the night. In most of the devices available in the current market, there are separate systems for overtake assistance and headlamp control. But there is no system available that integrates both of these into one single package. The use of image processing to detect oncoming vehicles is another highlight which is much more accurate as compared to ultrasonic sensors. The use of GPS or real time video transmission requires a constant high speed network that is not available in our country at all locations.

3.Methodology

The work aims at increasing the safety of passengers in vehicles, and aids the driver to judge and an oncoming vehicle or a blind curve. The sensors will indicate and notify the drivers the best possible time to overtake. With the help of a MATLAB toolbox the image processing of each frame captured by the camera is detected, the objects are compared with the reference data, algorithms are applied to these frames based on predetermined constraints. The system prompts the user with the necessary speed and distance required for a successful overtake. A smart headlight system that can improve visibility and reduce the headlight intensity on oncoming vehicles on a city or a highway is designed. Accidents occur at a higher rate during night as the headlight falls on the windshield of oncoming traffic. According to a slope or a curve head lights are self.

In Computer vision and Image Processing foreground detection is one of the major tasks involved. Background subtraction is the technique involved to extract the foreground object for further processing. The foreground detection must be able to develop the background model by estimation and must be able to be responsive even to changing and robust changes that would happen to the lighting, movements that are repetitive (say, leaves, waves, shadows) and long-term changes. Here, the background must be regularly updated to adapt to varying luminaries conditions and geometric settings. The values like, bounding-box, label matrix and the blob count are done using Blob Analysis in MATLAB. The algorithm is used to generate the image pyramid where every level needs to have a lower resolution in comparison to the earlier level.

The algorithm tracks the point at the multiple level in resolution when the pyramid level is greater than 1, where it starts at the lowest level. As the pyramid levels are increased, the algorithm performance improves. When the pyramid level is selected greater than 1, the algorithm track the points at multiple level of resolution, starting at the lowest level. With the increase in the number of pyramid levels enables the algorithm.

3.1.Block diagram and design

Using an ov7670 camera module, video data is acquired and is processed using MATLAB software. To simulate the steering angle sensor potentiometer is used to simulate the steering angle sensor and a GY-521 gyroscope is used to measure the acceleration of the vehicle at different axes of orientation. In the Figure 1 shown all sensors are connected to the controller module and coding decides whether the high beam or low beam strip is illuminated. The data from the gyroscope and the potentiometer are used to send signals to the servomotor so that it can turn the headlight array to illuminate curved roads. The image data from the camera module is processed using the MATLAB code and the controller is programmed to indicate whether maneuver is safe or not. Potentiometer is used as a steering angle sensor. This potentiometer is to be placed at the steering column of the vehicle and it turns as the steering is turned. This change in the steering output is detected by the potentiometer and the steering angle data is sent to the controller.

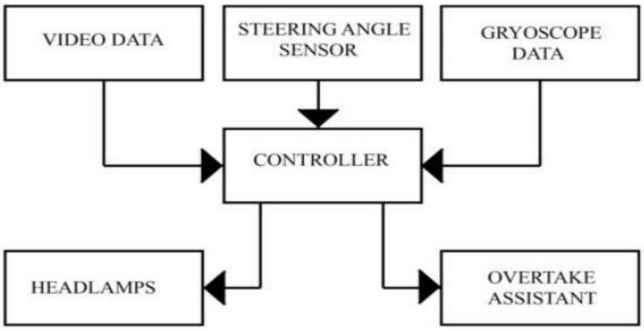

Fig. 1. Block diagram of an overtaking assistant system

The headlight array consists of 2 LED strips which are used as the low beam and high beam lights. The controller processes the sensor data and gives an output to the headlight array whether to turn on the low beam or high beam strip. The headlight array also has a servomotor which is used to turn the entire system towards the right or left to better illuminate the road during curves. A camera module is used to detect the oncoming vehicles on the road. The camera module will be integrated within the headlight array and will be used as a single module. A simple relay is used to switch between the high beam and low beam strip.

4.Results

By implementing the overtaking assistance and Smart headlamps on road vehicles as a standard feature it would help and aid the driver in taking better decisions while driving, as fully autonomous cars arrive people will not be initially comfortable to allow the vehicle to do things on its own. With the implementation of such minor tweaks to the car, it will allow the driver to depend on the car more well as help in people getting comfortable, rather than directly depending on fully autonomy of the vehicles. The number of fatal accidents caused due to overtaking and Troxler's effect also can be reduced by very large margin. Night driving can be encouraged as the temporary blindness effect can be minimized.

4.1.Vehicle Detection and Tracking

Fig. 1. Detection and Tracking using MATLAB

The video is captured using camera, from frame foreground extracted using Background Subtraction method. Background frame is captured for every fraction of second. Each time the vehicle is tracked from the image frame.

Prototype:

As seen from the above figures 4 and 5, it is observed that when the model is tilted more than the threshold value, the high beam lights are turned on. This is due to the gyroscope which gives a signal to the controller board if the threshold value is reached. There are 2 servo motors used to turn the low beam headlights according to the curvature of the road. A potentiometer is used as the steering angle sensor. When this is turned towards the left, the servomotor controlling the left side headlights turns the low beam strip slightly towards the left side. When the steering is turned to the right, the right side strip is turned slightly towards the right side. This simulates the turning of headlights when there is a curvature in the road.

4.2.Night Detection of a vehicle

By using the Optical flow technique of Gunnar Farneback, the direction of the moving objects are determined and their flow with respect to the observer. The Background subtraction technique is used to differentiate the foreground and recognize it, so that it can be taken as an input. When an object is detected this input is used to vary the direction of the headlights and also indicate the driver that the overtake is unsafe. The headlights are dimmed if in case they are turned on to high beam, and a signal is provided to the driver that it is not safe to overtake.

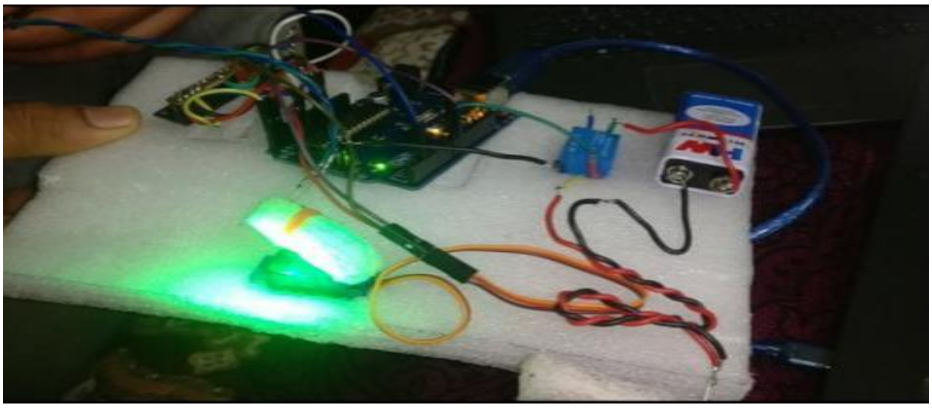

Figure 1: Prototype Test Circuit

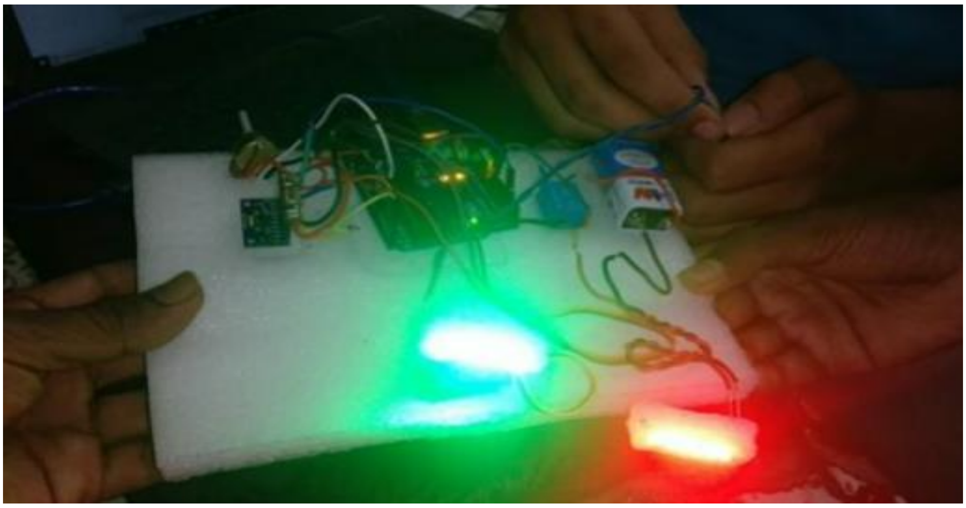

Figure 2: High Beam Testing

Figure 3: Low Beam Testing

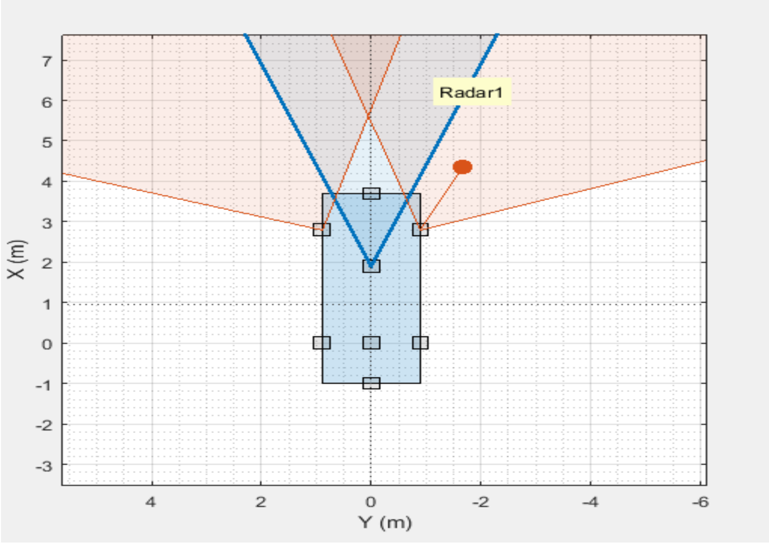

Figure 6.a. Ego-Centric View Simulation using MATLAB

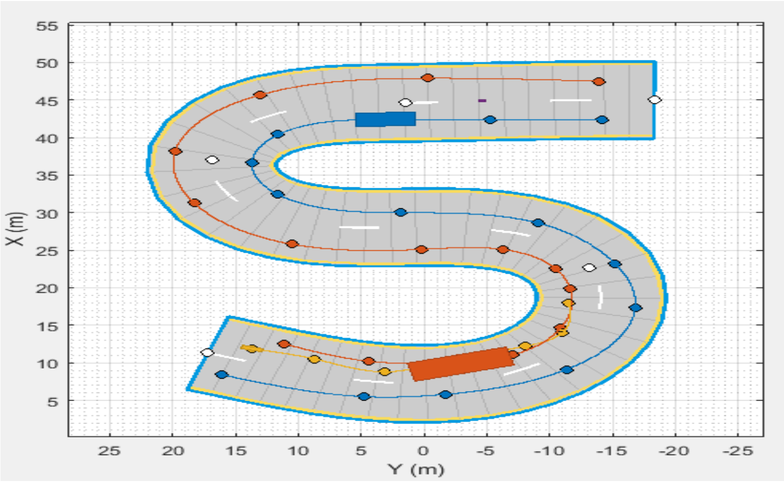

Figure 6.b. Curved Road Simulation using MATLAB

Figure 7: Detection of a Vehicle during Night

The Background subtraction technique is used to differentiate the foreground and recognize it, so that it can be taken as an input. When an object is detected this input is used to vary the direction of the headlights and also indicate the driver that the overtake is unsafe. The headlights are dimmed if in case they are turned on to high beam, and a signal is provided to the driver that it is not safe to overtake. The driving scenario designer application of MATLAB is used to simulate the vehicle, as it is much safer to test like this rather than to simulate in real world conditions. A typical road scenario is designed consisting of an S-curve and various obstacles and objects are placed for the camera and radar sensors to detect. By doing so we get an approximate location to place our camera on the vehicle and the range of detection and the drawbacks is understood.

Figure 8: Prototype Model Headlights

A potentiometer is used as the steering angle sensor. When this is turned towards the left, the servomotor controlling the left side headlights turns the low beam strip slightly towards the left side. When the steering is turned to the right, the right side strip is turned slightly towards the right side. This simulates the turning of headlights when there is a curvature in the road.

Table I Accuracy Of The Designed System Tested Through Simulation. The Number Of Test Conducted=15

	Overtaking Assistance	Headlamp Adjustments
Number of True Positives	13	11
Number of False Positives	2	4
Accuracy (in Percentage)	86.67	73.33

The overtaking assistance showed a good response which could be further improved by tuning. The headlamp automatic adjustment however shows room for improvement. The system has to be tested further using different Image processing algorithms which could prominently increase the accuracy.

5.Conclusion

Headlamps successfully illuminate the curved path as needed, thus improving the visibility for the driver during night driving. The curved path is appropriately illuminated to avoid accidents and hence reducing the risk of accidents due to poor visibility. The beam intensity control using the Arduino board is an important safety feature for night driving since it ensures better visibility for the driver when an oncoming vehicle has a high intensity light. This will prevent a large number of accidents which occur due to the negligence of drivers since they do not switch to low beam when necessary.

The beam intensity is also controlled when there is an elevation in the path so that the driver can easily see the road. Using MATLAB, detection of oncoming traffic and pedestrians was successfully achieved. This again is an important safety feature since it can aid the driver in deciding when to overtake safely. Various scenarios were simulated both during day and night time and hence detection of cars, bikes, pedestrian and other obstacles was achieved the technology used in this system can be integrated with any automobile available in the market and it will help reduce the number of accidents occurring on the road by a substantial amount.

The model is a cost effective system which is affordable for people from all walks of life which is the unique selling proposition of this product. By using modern hardware equipment's we can get a better output from this project, which can be used for live tracking by integrating the system with camera of suitable features. The code has potential to be optimized even further, so that the processing can be made faster overall.

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