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Development of Adaptive Front Light Systems

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***Abstract*— Adaptive front light systems aim at automatically adjusting the headlamps beam of the vehicle to illuminate the road ahead as much as possible without causing any discomfort to other drivers. The proposed system focuses on building a prototype of adaptive front lighting system that improves the night time illumination of the curved roads to the driver. In this proposed system, unlike the traditional AFS which uses steering wheel for the headlamp's horizontal adjustment, we are using a camera as a sensor to adjust the horizontal rotation of the headlamps. Camera is used as image sensor to detect and capture the details of the curved road ahead of the vehicle. As a result a suitable light beam with improved road illumination is obtained for the curved roads. This will lead to better illumination and safety at the curved roads.**

***Index Terms*— Adaptive Front Light System, curved road, image sensor, horizontal and vertical adjustment, headlamps, glaring.**

I. INTRODUCTION

As the automobile industry developed over the years, there was a great increase in the number of vehicles resulting in the increase in the number of road accidents. Road accidents at night time are more serious and result in more fatalities. In the research, we found that approximately 60% - 70% fatal vehicle - pedestrian accidents take place at night time. Poor visibility or improper illumination of the roads at road corners, curves and of surrounding area results in accidents. The main cause of most of the accidents occurring at night time is generally the driver fails to see the obstacle or the pedestrian and react in time or apply brakes in time.

The headlamps play a very crucial and major role in the drivers visibility and safe driving. The fixed lighting pattern of the headlamps create blind spots at the road corners while turning and it also limits the drivers sight to the emitted light beam range. Based on this, the AFS system has come into being. Adaptive front-lighting system (AFS) is an active driving safety enhancing system which can automatically change or adjust headlamps for different external conditions or factors such as road conditions, driving conditions and weather conditions etc. AFS relies on transducers, electronic sensors and actuators, unlike earlier directional headlamp systems that used the mechanical linkages.

Headlamps with AFS illuminate the curve of the road when the vehicle is turning at the curved road. Comparison of headlamp light distribution patterns with AFS and without AFS shows that the headlamp without the AFS do not make the full curved road illuminated which blocks the driver from detecting any pedestrian in the way of the vehicle. The headlamp with AFS is able to illuminate the curved road fully which as a result does not block the driver from detecting the pedestrian in the way of the vehicle. Therefore timely detection of the pedestrian leads to timely avoid any accidents or collision at the curved road.

This paper proposes an automatic adaptive front-lighting system based on camera sensor which is better than the traditional AFS which were dependent on the steering wheels for the adjustment of the headlamps. This new kind of AFS uses image recognition technology to gather the curved road or corner details in advance from a certain distance. Then it adjusts angles of the headlamps in advance according to the road curvature details gathered. This will lead to proper illumination of the curved road surface. This way, it can adapt to curved road condition in advance through camera sensor without any need for the calculation based on the steering wheel angle sensor.

A lot of work and research has been done in improving the headlamps of vehicles so that the night time driving can become more safe and comfortable. The earliest of the vehicles used headlamps of acetylene oil, then electric headlamps were developed. After this came the headlamps with high and low beams. Then the halogen headlamps were developed followed by the xenon lamps and the high intensity discharge (HID) systems and more recently the LEDS were introduced. The automatic systems for headlamps developed and became available since the1950s originally only on the luxury models. Beginning in the 2000s, there was a resurgence in interest in the idea of moving or optimizing the headlight beam in response not only to vehicular steering and suspension dynamics, but also to ambient weather and visibility conditions, vehicle speed, and road curvature. Manufacturers such as BMW, Skoda, Toyota have been working on AFS.

The work proposed by C K Chan, K. W. E. Cheng, S.L. Ho, and T. M. Fung [3] is based on the traditional AFS system which adjusts the headlamps in horizontal direction according to the steering wheel angle, the pitch and adjusts the headlamps by detecting the vehicle in front. They have also worked on the leveling of the beam according to the load in the vehicle. In the work of Yali Guo, Qinmu Wu and Honglei Wang [4] the motion models of headlights are established and turn angle of the headlamps in horizontal and vertical direction can be calculated by mathematical equations the design of the system is put forward. Hardware and software of the intelligent headlamp control system is designed. Control algorithm uses the fuzzy control, and fuzzy controllers are designed. In [1], work aims to design and build a prototype of steerable headlights by adapting a

conventional static headlamp. Literature [6] analyzed photometric characteristics of vehicles headlamps when turning the corner, and developed a new kind of AFS (Adaptive Front Lighting System) based on CCD (charge – coupled device) which was better than traditional AFS.

II. SYSTEM OVERVIEW

The proposed AFS system consists of basically the sensor blocks, controller block and the actuator or motor block. The sensor block provides the input to the system which is then processed by the controller and then the output is obtained in the form of actuator movement.

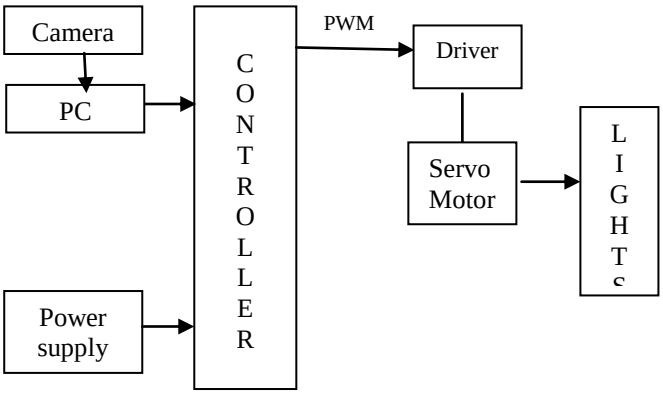

Figure 1. Basic Block Diagram of System

In this paper, the proposed system focuses on adaptive front lighting systems using camera which enhances driving safety at night time.

When a vehicle is coming near to a curved road, the camera captures the condition of the road ahead. Image recognition and processing is done on the captured road image and details of the road curvature are obtained, that is, the slope of the white line on the road is obtained and sent to the controller unit. Then algorithm processing is done on the obtained slope of the white line by the controller. The processed information is sent to drive the motors and adjust the motors at the required angle. The lights are adjusted horizontally or there's a angular movement of the lights according to the curve of the road. The motors are given a PWM input from controller to move accordingly towards left or right. Due to automatic horizontal adjustment of the headlamps at the curved roads, obstacles can be detected in time and accidents can be avoided.

III. HARDWARE

In the proposed system LPC2148 microcontroller is being which is based on 16bit/32 bit ARM7TDMI-S CPU with high speed flash memory ranging from 32kB to 512kB. Serial communication interfaces, multiple UARTS, SPI, 10- bit ADC, 10- bit DAC, PWM channels and fast GPIO lines are some important features of the controller for which the LPC2148 was chosen.

Servomotors were selected as they are more suitable for the AFS system design as the servomotors contain inbuilt feedback mechanism for motor positioning and accurate motor positioning is the important criteria of the proposed system.

IV. SOFTWARE

In the programming part, image processing is done by using MATLAB and C programming is used to generate a PWM signal from the angle of the white line of the road obtained using MATLAB which is given as input to the servomotor.

The various operations like RGB to gray conversion, thresholding, morphological operations of image recognition and processing are performed on live scene from the camera to obtain the desired result of the angle value of the white line of the road.

Morphological operation is a collection of non-linear operations related to the shape of features in an image. Morphological operations that we have used are erosion and imfill operations. The operation erosion of a structuring element shrinks the image and performed to remove unwanted noise. The imfill function performs a flood-fill operation on binary and grayscale images. For binary images, imfill changes connected background pixels (0s) to foreground pixels (1s), stopping when it reaches object boundaries. For grayscale images, imfill brings the intensity values of dark areas that are surrounded by lighter areas up to the same intensity level as surrounding pixels. (In effect, imfill removes regional minima that are not connected to the image border). This operation can be useful in removing irrelevant artifacts from images.

The formula used to find the slope using MATLAB is

slope = ((avg2 - avg1) /4)+30

angle = 60 - slope

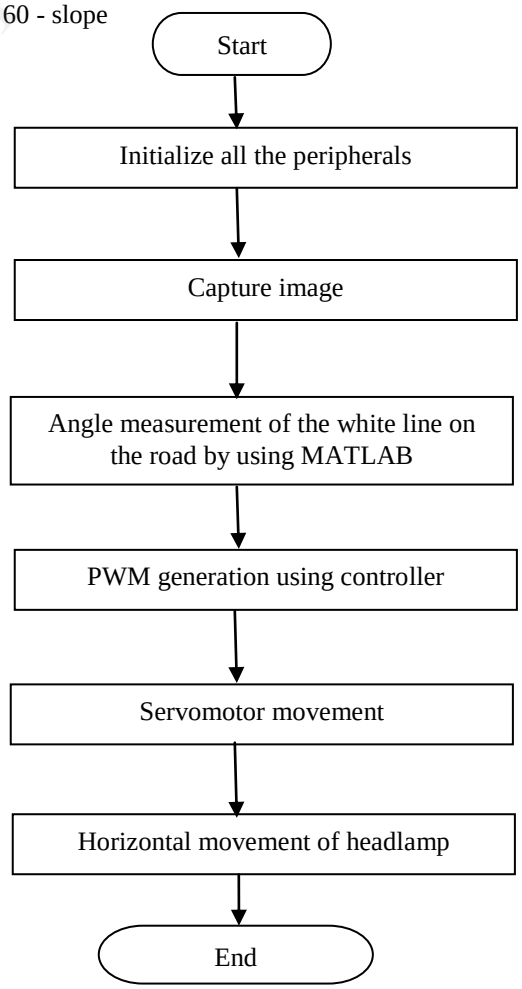

Figure 2 : System Flowchart

V. RESULT AND DISCUSSION

Image processing is done on each frame of the live scene from the camera. The following figure shows one of the frame captured and the result of the image processing done over it to obtain the angle of the white line. The changing figures point towards the changing angle of the white line and it indicates that the line is not a straight line. Angle is calculated for a single frame.

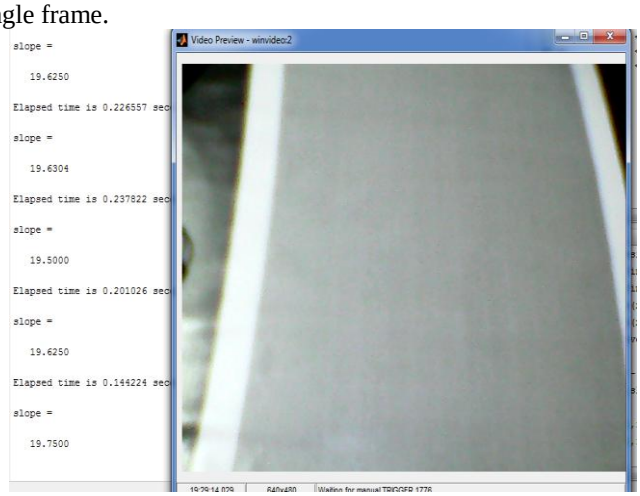

Figure 3: Angle measured of the white line on road

Figure 8. MATLAB processed output of the frame

VI. CONCLUSION

This paper presents the automatic horizontal movement of the headlamp by capturing the road image and then calculating the angle of the white line. This automatic horizontal movement of headlamp results in proper illumination of the curved road surface. And thus make driving at night time safe and comfortable.

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