Design and Development of Adaptive Front Light System (AFS)

Adhiraj Kadam[1], Jubin Sharma[2], Naitik Mehta[3], Arpan Patel[4], Prof. Hansraj Khande[5]

[1234] B.E. (Mechanical), Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering, Pune, Maharashtra, India.

[5]M.E. (Mechanical, Design) Asst. Professor, Smt. Kashibai Navale College of Engineering, Pune, Maharashtra, India.

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Abstract – *In visibility region of the car driver is better at daytime, is constrained at night time due to limited illuminated region. This may be due to lack of street lights which has increased the road mishaps. To achieve the solution for stated problem, we present the basic concepts of this new way to light roads, called Adaptive Front Light System (AFS). This work is aimed to increase the durability of the lighting system of four-wheeler or any vehicle other than two-wheeler on the basis of movement of steering wheel with greater accuracy and cost effectively. For this model, we are using different sensors like ultrasonic sensor for horizontal displacement of headlight and accelerometer of vertical movement.*

***Key Words*: AFS, Headlamp, Ultrasonic Distance Sensor, Accelerometer**

1.INTRODUCTION

Although only a small part of travels by car are carried out after the sunset, 40% of fatal and serious injuries take place during night time. Also, Given that public lighting is mainly limited to urban areas, this figure gives us a significative idea of how deep the impact of accurate vehicle lighting is. [1] Thus, we do need a way to increase the vehicle safety at night. Lighting system plays important part in night driving. Hence we need to improve the lighting system. The objective of lighting system is to see and to be seen by others. Thus car manufacturers continuously improve their products with latest technologies like daytime running lamps, use of light emitting diodes (LED), cornering lamps etc. Besides all these, there is one innovation which imposes large impact on night driving safety, and that is 'Adaptive Front Light System' (AFS)

Although the objective of AFS sounds simple, the complexity of system needs an exact idea about what the adaptive front light system is. An adaptive front-lighting system is defined as in ECE324-R123 as "a lighting device, providing beams with differing characteristics for automatic adaptation to varying conditions of use of the dipped-beam (passing beam) and, if it applies, the main-beam (driving-beam) with a minimum functional content; such systems consist of the "system control", one or more "supply and operating device(s)", if any, and the "installation units" of the right and of the left side of the vehicle" [2] But in a simple way, it is defined as an optimization of light distribution from the headlights according to driving circumstances.. Depending on vehicle speed and steering ratio, the system points the headlights in the direction the driver intends to travel.

2.PROBLEM STATEMENT

The problem for the major road accidents at night time is the limitation on visibility region. Due to lack of street lights outside the urban areas, the driver is unable to focus on the area other than the area in straight line of the headlights. Also, on the upward slope, normal headlights focus straight which fails in illuminating the road. Similarly, on the downward slope, the light goes on the road upto a little distance which darkens the far region. These drawbacks conclude in decreasing driver's efficiency to drive safely.

3.OBJECTIVE

The main objective is to create an active safety system for night time driving. This includes the following objectives.

1) To increase the visible region on the corners, i.e. to eliminate the blind spot at corners.
2) To assist the driver for seeing the near and far regions on upward and downward slopes respectively.

Other objectives of the work include:

1) Develop the conventional headlight system into an advanced system by implementing an active safety system.
2) To make the new technology available for common vehicles cost effectively.

4.METHODOLOGY

The objectives are achieved by designing a model for the horizontal and vertical movement of headlights. For this, we used the sensors like ultrasonic sensor and accelerometer for horizontal and vertical movement of light beam respectively. The output of the sensors is given to the arduino uno microcontroller as input. We used stepper motor for horizontal and vertical movement of headlights. Thus the microcontroller processes the input and gives corresponding signal to the drives controlling the stepper motors. Thus we get the corresponding result in angle turning. Different iterations were done for better angle turning and better visibility by elimination of blind spot.

5.CONSTRUCTION AND WORKING OF ADAPTIVE FRONTLIGHT SYSTEM:

5.1Components:

A)Base Model:

The base model of the system is as shown in fig -1. It is designed so that we can fix two headlights on it. Also, we are using the steering system of Maruti 800, which consists of the tie rod assembly that works on Ackermann Steering Mechanism. The principle of Ackermann mechanism works on the difference in turn radius between the front tires. On oval track cars it can be desirable to create a situation where the left front tire turns faster than the right front tire. The Ackerman effect can help the car turn better through the center of the turn. The steering system works on rack and pinion arrangement which converts the rotating motion of the steering wheel into translator motion of the tie rod. The base model (chassis) also has the arrangement to hold the 2 headlights as shown. The designing dimensions were taken so that it balances the weight of overall system.

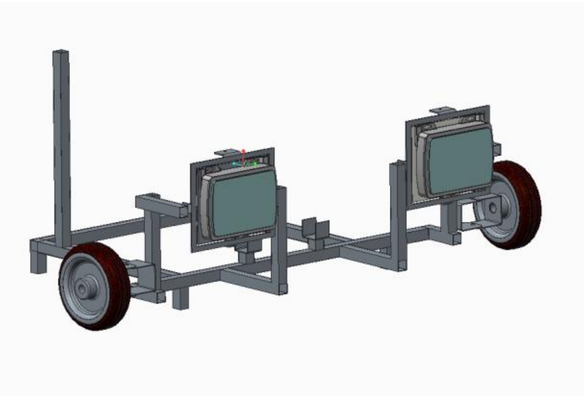

Fig -1: Designed Model (Isometric View)

B)Arduino Uno:

For control and processing purpose, we used the Arduino Uno microcontroller. Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control the physical world. This microcontroller was chosen due to its simple working and the program code is generated easily. The microcontroller is as shown in fig -02. [6]

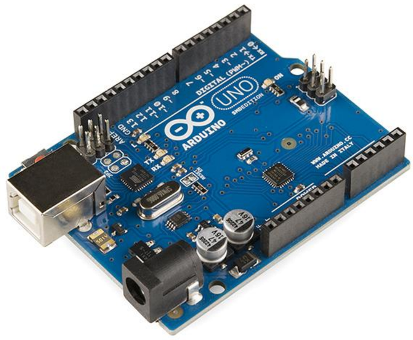

Fig –2: Arduino Uno Microcontroller

This controller receives the output from ultrasonic sensor and accelerometer and processes the input according to the program and gives the output to the drivers of stepper motors.

C)Sensors:

1)Ultrasonic Distance Sensor

Like the bats and dolphins do, ultrasonic sensor senses the distance of the object placed in front. It offers excellent non-contact distance sensing with high accuracy. It can work for the distance ranging from 2cm to 400cm. The one we are using is HC-SR04. It has 4 pins as following:

- VCC= +5V
- TRIG= Trigger input of sensor
- ECHO= Echo output of sensor
- GND= GND

To start measurement, Trig of SR04 must receive a pulse of high (5V) for at least 10us, this will initiate the sensor will transmit out 8 cycle of ultrasonic burst at 40kHz and wait for the reflected ultrasonic burst. When the sensor detected ultrasonic from receiver, it will set the Echo pin to high (5V) and delay for a period (width) which proportion to distance. To obtain the distance, measure the width (Ton) of Echo pin. [3]

In our model, we are using the ultrasonic sensor to assist the horizontal movement of headlights in accordance with the rotation of steering wheel. We fixed the sensor on moving part of tie rod, and a piece of acrylic sheet is placed on non-moving part of assembly right in front of the sensor. Hence as we rotate the steering wheel, the distance between the fixed surface and the sensor changes which generates the corresponding signal and send it to the Arduino Uno as input. Fig -3 shows used ultrasonic sensor HC-SR04. [6]

Fig -3: Ultrasonic Sensor

2)Accelerometer

For vertical movement of headlights, we are using the accelerometer. The ADXL335 is a complete 3-axis acceleration measurement system. The ADXL335 has a measurement range of ±3 g minimum. It contains a signal conditioning circuitry to implement an open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration. In our system, accelerometer measures the static acceleration of gravity from the tilting of system, i.e. as we get vertical tilt, accelerometer senses the acceleration and gives signal to Arduino . The microcontroller reads the signal and sends output signal to the drivers of the motors which are responsible for vertical motion of the headlight. We fix the X and Z axis of accelerometer, hence it senses the motion along Y axis. Fig -4 shows the accelerometer ADXL 335. [6]

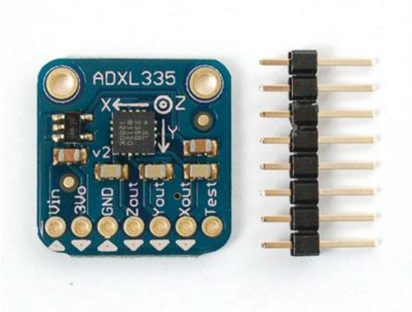

Fig -4: Accelerometer ADXL 335

D)Drivers

The function of the driver is to control the stepper motor. The one we used is a PWM chopper-type IC-designed stepping motor driver for sinusoidal-input microstep control of bipolar stepping motors. We have used two Toshiba TB6560 drivers, one for the stepper motors controlling horizontal movement and one for stepper motors controlling vertical movement. These are very high capacity drivers which can withstand the temperature upto 170 TB6550 is as shown in fig -5. [6]

Fig -5: Stepper motor driver (TB5650)

E)Stepper Motors

A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotations. Each rotation of a stepper motor is divided into a set number of steps, sometimes as many as 200 steps. The stepper motor must be sent a separate pulse for each step. We implemented two pairs of stepper motors. In each pair, one controls the horizontal movement of headlight and other controls the vertical.
We used the hybrid type of stepper motor. Hybrid-type stepping motors consist of a rotor with permanent magnets and magnetic bodies, and by using Minebea's high-precision ball bearings they can perform highly precise and reliable motions. Fig -6 shows stepper motor. [6]

Specifications:

Type	20mm square type
Step Angle	1.8˚
Step accuracy	±5%
Temperature rise	80˚C max
Ambient temperature rise	-10˚C~+50˚C
Radial play	20µm Max
End Play	80µm Max

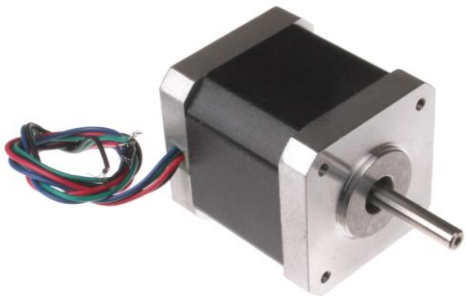

Fig -6: Stepper Motor

Fig -7 shows the assembly of AFS system.

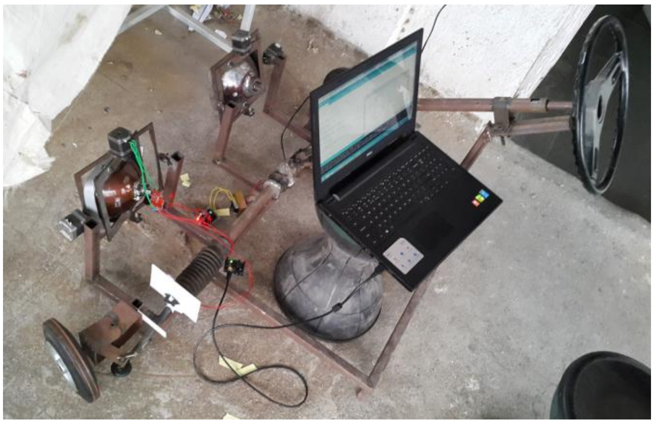

Fig -7: Assembly of System

6.WORKING

The code is first saved in Arduino microcontroller. At first, the headlamps are at normal position. When the supply is given, the system activates. Now, as we steer the steering wheel in anti-clockwise direction, the tie rod moves towards right. This increases the distance between ultrasonic sensor and the acrylic sheet placed infront of it. This generates the signal in the Arduino which sends the output signal to driver controlling two stepper motors responsible for horizontal movement, and the headlamps are turned towards left hand side. Similarly process repeats as we turn the steering wheel in clockwise direction.
When the system is placed at upward slope, the the accelerometer senses the acceleration and sends signal to the Arduino. It works on the input according to the saved program, and sends output signal to the driver controlling stepper motors which are responsible for vertical motion of headlamps. Thus headlight is lowered by the relative angle. Similar process goes for downward slope. By iterative method, we have set the horizontal spam of the headlights to 60˚ (30˚ each on left and right) and the vertical spam is fixed to 20˚ upwards and 20˚ downwards from normal axis.

7)CONCLUSION

a) This paper presents a newly developed adaptive front lighting system for vehicle. This developed architecture helps to remove “blind spot” and improve the driver’s visibility at night time.

b) This paper propose the new system which is based on ultrasonic and accelerometer as input sensor to adjust the horizontal and vertical movement of headlamp and this newly proposed Adaptive front lighting system (AFS) helps to improve driver’s visibility at night time hence achieving enhance safety. The future work mainly concentrates on to invent an AFS system which can be suitable for complex road conditions, corner, highway, rural road and urban road and so on.

c) The traditional headlamps stop being simple projectors, i.e. they can do additional work besides just focusing in front direction and advance the light beam in right direction for better safety.

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