Adaptive Headlight Control System

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Abstract. This research paper focuses on the new method of a retrofittable Adaptive Headlight Control System (AHS) for automobiles like car, trucks, etc., Adaptive headlight system is the technology where the headlights can adjust their illuminating radius with respect to the steering angle and able to self-level its position depending upon the terrain and intensity of light beam changes dynamically high or low according to the oncoming vehicle. This system also considers the benefit of other motorists on the road. In the existing system, mechanical links are incorporated with the front lighting system and steering wheel, and the angle of light will change according to the requirements and the cost of this system is high which is mostly used in higher-end vehicles. In this study an attempt is made to develop a adaptive headlight system which can be retrofitted in an existing model of an automobile providing improved illuminating angles and light visibility under various terrain and road conditions. The proposed AHS system could be useful for applications like different lighting beams (low, high) and also for levelling operations. This system could be a better replacement for conventional headlights seen in low, mid-end cars and would help in the prevention of accidents especially during night driving.

1. Introduction

Night driving is quite different from normal day-time driving. Without natural light, the field of view of the human eyes will naturally get reduced. The driver feels less confident on the lighting conditions during night travel. The headlight systems are responsible for providing lighting until the vehicle reaches its destination. In contradictory, accidents during night travel happens mostly due to vehicle front lighting system and it is a major problem for the motorists. The conventional headlights illuminate the road ahead but while traversing some bends or curves the illumination may not be sufficient leading to blind spots responsible for accidents. The most common reasons for accidents at night-time are low visibility and difficulty in viewing an obstacle at bends or corner of the road. The blind spots zone is where the driver cannot easily observe the oncoming vehicle. This zone cannot be directly seen by the driver or with the side mirrors. Some other reason for blind spot zones are due to steep curves in roads, less visibility due to weather conditions, etc.

In order these visibility problems, the popular lighting brands like Philips, OSRAM started developing high-power white LEDs. But the intensity of these lights from the oncoming vehicle are high and hence it causes a discomfort to the drivers. This discomfort glare leads to an accident on highways and also affects the driver’s vision. In order to address these problems there is a need for the development of headlight system which would illuminate according to the road conditions. The headlight system should be such that it adapts to the geometry of the path being traversed and hence it illuminates the road uniformly without any blind spots. The cost of available adaptive headlight systems are too high for it to be implemented in low and mid segment cars. In such AHS, a dynamic dimming system is also
implemented so that the intensity of light gets converted to low beam automatically whenever there is an approaching oncoming vehicle and thus eliminating the discomfort for the oncoming vehicles due to the glare from the high-beam light. The adaptive headlamps system is not new in the market, higher-end luxury cars like BMW, Audi, etc. use these kinds of systems. These luxury car brands use expensive sensors and control systems to measure speed, yaw, angle of steering and accordingly operate the headlight systems by rotating their reflectors which changes the illumination angle [1]. In the proposed system, the core idea remains the same but the implementation approach is little different compared to conventional systems in order to make it more affordable. A hardware loop model has been utilized for adaptive headlights in order to achieve dynamic light distribution [2].

The adaptive headlight systems were also designed with the help of a stepper motor that provides stepwise turns of the headlamps on either side. The maximum degree of turn achieved on the left headlamp is 20 degrees and on the right-hand side is 30 degrees [3]. The perceived discomfort glare from different adaptive driving headlight system has been reviewed and there is an absence of a system to decrease these discomfort glares which led to many pedestrian accidents [4]. In this paper an attempt is made to design and develop an adaptive headlight system which is affordable compared to the existing systems. The proposed AHS provide proper illumination an all terrains to assist the driver during night-time driving. The variety of lighting techniques available for autonomous vehicles have been reported in literature [5]. In the current effort a new method is followed to develop the headlight system which is built with the vehicle speed sensor and stepper motor setup and the electronic levelling sensor has been incorporated to level the headlights in the uphill and downhill roads [6]. A matrix LED headlight system [7] and control of headlight has also been attempted based on the surrounding lighting conditions [8].

2. Methodology

2.1. Proposed System

The main objective of this project is to design and develop an adaptive headlight system which is cost-effective, easy to retrofit in low and mid-end vehicles. The methodology followed is shown in figure 1. The proposed AHS is developed using servo motors attached with the headlights for swiveling operations and placing of gyroscope sensor in the body of the car for levelling the headlights and using the light sensor to dynamically control the high and low beam.

![Figure 1. Block diagram representation of the proposed system](image-url)
2.2. Experimental setup

The experimental setup of the adaptive headlight system consist of the following components as listed in table 1.

| S. No | Name                        |
|-------|-----------------------------|
| 1     | At Mega 2560                |
| 2     | BH-1750                     |
| 3     | MPU 600                     |
| 4     | MG 995 servo                |
| 5     | Automotive relay switch     |
| 6     | LM-2570                     |
| 7     | 12v Battery                 |
| 8     | L298N driver                |

2.2.1. Component description

The AT mega 2560 is a microcontroller-based board having 54 I/O pins with 16 analog pins, 16 MHz crystal oscillator, and 15 PWM pins. This micro controller has voltage regulator that keeps the voltage constant at 5v. Arduino IDE is a proprietary software platform of arduino boards for easy programming. The automotive relay is utilized to activate the multiple connection through a single switch. The servo motor MG995 is a low cost and also good in performance which has a torque of 9.4kg/cm (4.8v) to 11kg/cm (6v) is utilized for performing levelling operations efficiently. The BH-1750 ambient light sensor measuring ranges up to 50000lux is used to detect the intensity of the light from oncoming vehicle. The MPU 600 is a gyro sensor with three axis detection sensor which is combination of both 3-axis gyroscope and 3-axis accelerometer used to detect data of pitch axis and send the data to controller to adjust the headlight and for levelling operation. This is a low-cost sensor which is easy to interface with the board and has a good efficiency compared to the other gyro sensors.

3. System Architecture

The prototype setup is shown in figure 2. In this system the arduino mega 2560 acts as a main controller which controls the head light, sensors, servo motor and the relay switch. The total system is connected with the 12v dc battery and the battery output is connected with the LM 2574 switching voltage sensor where the 12v dc is regulated to the required 5v dc. The board and sensors require the 5v dc supply. The power supply unit to the servo motor has been separately bypassed with the L298N driver to supply 6v and the supply to the headlights are given directly from the power unit. The light sensor and gyroscope are interfaced with the arduino. The light sensor is placed in front of the vehicle to detect the oncoming vehicle light lux intensity. Once the intensity is measured, the sensor sends the value to the arduino board and the board sends the signal to relay. The automotive relay switch is used here to respond the light intensity data and accordingly it switches between high or low beam of light.

The servomotor is used to perform the swivelling and levelling operation and it is achieved by interfacing the potentiometer and servo with the help of arduino. The steering position or angle is measured using the potentiometer and accordingly the servomotor will swivels the headlight. The swivelling angle is set up to 43 degree in right and 34 degree in the left. The gyroscope sensor has been placed in the vehicle and it measures the pitch axis for the leveling operation. According to the signal received from the sensors, the microcontroller process the signal and will send appropriate commands to the servo for headlights appropriately. Both swivelling and levelling operation are shown in figure 3.
Figure 2. System architecture design of adaptive headlight system

Figure 3. 3D and real time representation of Headlight mechanism

4. Result and Discussion
The circuit diagram of the proposed prototype is shown in figure 4. The entire circuit is interfaced with the help of breadboard. All four servomotors are connected with the arduino mega in the following pins of 8, 9, 10 and 11. The SCL and SDA pins of gyroscope sensor (MPU 6050) is connected to the SCL (digital pin 21) and SDA (digital pin 20) of the AT mega controller. Also, the BH1750 light sensor has its SCL and SDA pins connected to the SCL (digital pin 21) and SDA (digital pin 20) of the AT mega controller. The relay driver input pin is connected to the digital pin 7 of the AT mega. The feedback voltage from the steering angle sensor is connected to the AT mega through analog pin A0. The overall system is powered from the 12v Lead acid battery. The circuit setup for the prototype has been setup with the help of breadboard for easy connections. The SCL and SDA pins are the serial data line and clock line which helps to synchronize the data transfer between the devices through the I2C bus like gyroscope and the light sensor.
The developed prototype model is shown in figure 5. The prototype setup is developed using PVC pipes. The frame design resembles like typical steering setup seen in a four-wheeler. The control system is placed in the middle of the frame and the headlight is fixed in the front of the frame. Every component is properly fastened in the acrylic sheet. The steering angle sensor and the automotive relay is fixed in the steering setup of the frame. The BH 1750 light sensor is placed in the front of the setup for detecting the light from oncoming vehicle and the MPU 6050 gyroscope sensor is placed above the frame to detect the pitch of the vehicle.

In the developed system the lights were observed to turn successfully for a degree of 43 in the right and a degree of 34 in the left. This will provide a comfortable lighting to the driver. The blind spots in the turns can be identified easily with this system. Another major problem while driving in the night is the is the discomfort for the oncoming vehicles due to high beam lights form the approaching vehicles and this has been sorted out by providing automatic dimming of lights as and when an oncoming approaches the car. This provides a clear vision to the driver of the vehicle coming in the opposite direction. The hill assistance technique by levelling the lights automatically up and down according to the altitude or slope will help the drivers to drive safe in the hills. In this prototype, the levelling angle is achieved up to ± 30 degree and this will be optimized in real time model around ±6 degree. The levelling and swivelling function with respect to the gyroscope and steering angle sensor. The main objectives of the project have been successfully implemented in this prototype and the model has been found to work properly.

5. Conclusion
Thus a cost effective adaptive headlight system has been successfully developed in this study which can be retro-fitted in any of the passenger vehicles irrespective of their brands. The designed system achieves the swivelling and levelling operation based on the input from the sensors. The maximum degree of swivelling angle is 43 degree in right and 34 degree in left. The servomotor provides the adequate turns
at the bends. Hence the proposed adaptive headlight system prototype model is reliable and ensures the safety of the driver and helps in efficient driving. The prototype has been successfully tested and it meets all its objectives.

6. References

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