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Software Design for Adaptive Laser Headlights

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Abstract: The road traffic collisions and injuries, is still a major concern in automotive field. A disproportionate number of fatal accidents happen at nighttime. The major part of the collision is contributed by the human factors. Yet the technology in automobile is continuously assisting drivers while driving. Driving in the dark is not always easy as roads aren't always illuminated, in such cases a powerful headlight is needed to illuminate most of the road. But such headlights cause glare to the oncoming traffic and again the chances of collision increase, with risking lives of passengers. Therefore, a need of smart headlamps which can illuminate the road far ahead without glaring the oncoming traffic is generated. This research aims to build a Laser based adaptive headlight system which can fulfil the need. The headlight design is proposed using Tinkercad software in which Arduino circuit has been used and software design is presented. The system works well with responding to the steering angle and controls the intensity of light preventing oncoming traffic from getting glared.

Keywords: Adaptive headlight system, laser headlights, Arduino, Arduino software design, design of headlight system, cornering lights, effects of laser headlights, Tinkercad

I. INTRODUCTION

Driving at night adds risk to the lives of passengers. The invention of headlamps has reduced this risk. From the acetylene lamps to the electronic headlamps automotive world did great changes to the automobiles for safety. It was a challenge to create headlamps which could withstand any difficulties and comfort the driver. Despite the general improvement over the past few years the number of accidents at night are still counting.

The causes of accidents can vary over human factors and technical factors. Collision may occur due to poor lighting condition and less visibility. Sometimes getting glared by oncoming traffic can also lead to the accident. While taking a turn one may not see pedestrian or object in the less illuminated area due to the upright position of the headlights. These common mistakes are the prime reasons for the fatal accidents.

Automotive industry has already taken initiative into building moving headlamps. Car manufacturers like Audi and BMW have their own lighting technology which can light half a kilometer easily. They call it adaptive front lighting system. This system is capable of illuminating at a wide angle and also has solution against blinding oncoming traffic. Assisting driver with ease was the success of this technology.

The present technology of adaptive headlight system in the market works by using LEDs. LEDs are best known for high brightness and intensity. They are efficient and long lasting. Laser diodes are the future of headlights as they take one step further than the LEDs. Laser based headlights can illuminate road twice as much of LEDs. They are 30% more efficient than LEDs.

The laser diodes are powerful enough to injure a person. For the sake of safety, the lasers have to go through a procedure before reaching out of the headlights. The lasers are first redirected by a set of mirrors to a prism. This prism is used for directing a single light beam through it. This single beam passes through a lens filled with yellow phosphorous. Once the yellow phosphorus has been excited by the blue laser beam this yields a diffused white light, which is safer for human eyes. The white light bounces backwards to the reflector and then forwarded.

This project aims in building a prototype model of a laser headlight system which can redirect with changing the direction of steering and change the angle when the vehicle is tilted. It should also help oncoming traffic by dimming the intensity of light and prevent them by getting glared.

II. LITERATURE REVIEW

The researchers have created the optical module for laser headlamps by combining two reflective lenses to form a mirror set. When operating in high beam mode this set forms an oval shape and when operating in low beam mode the reflective lenses change their position with the help of a driving member. The invention eliminates the need of multiple lasers in the headlight module.[1] The inventors have invented/shown the working of a laser headlight. They have used phosphor as luminous element and reflector to direct the beam.[2] In this paper the researchers have developed a technology which could work as an emergency system. According to them, the adaptive front lighting system (AFLS) helps stability and visibility during nighttime driving.

In case of a system malfunction the AFLS system can lose control. In such cases another controller is needed. They have suggested the idea of a backup controller for AFLS which will take role after conventional AFLS system malfunctions.[3] In this paper, researchers have invented a system that controls the brightness of the headlight adaptively. The system works by capturing the intensity of the headlights of the oncoming traffic. They were also able to develop a technology wherein the control of the headlight can be given to the smartphone to find the vehicle in the dark.[4]

III. PROPOSED DESIGN

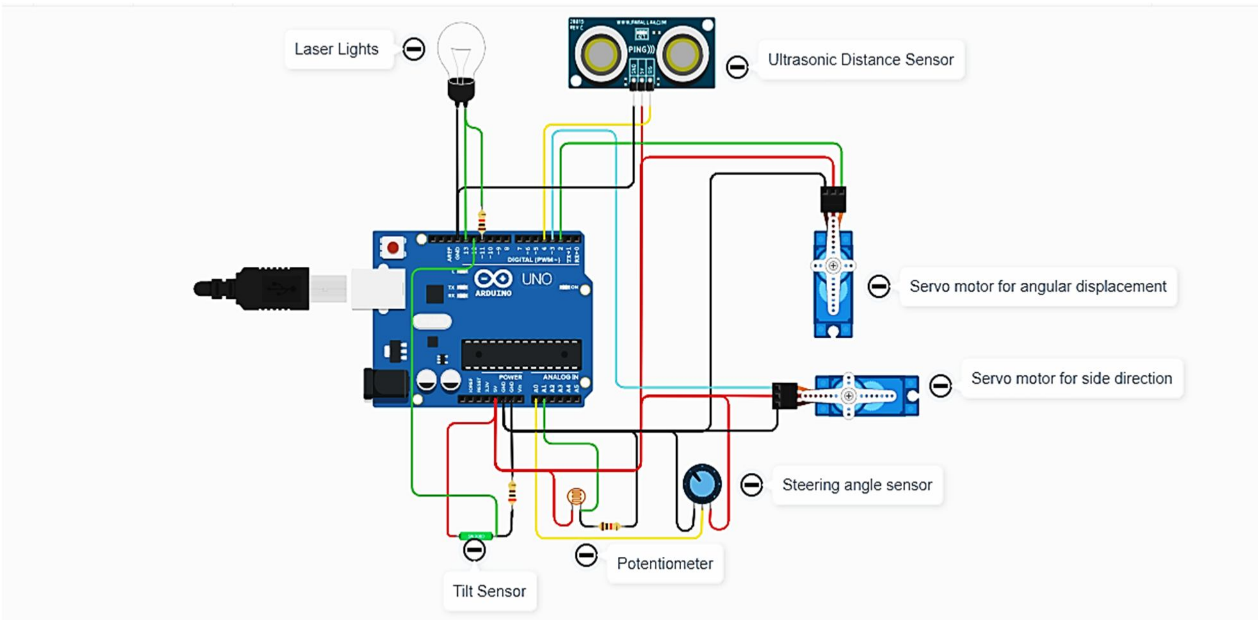

Figure 1: Circuit Design

IV. FUNCTIONAL BLOCK DIAGRAM

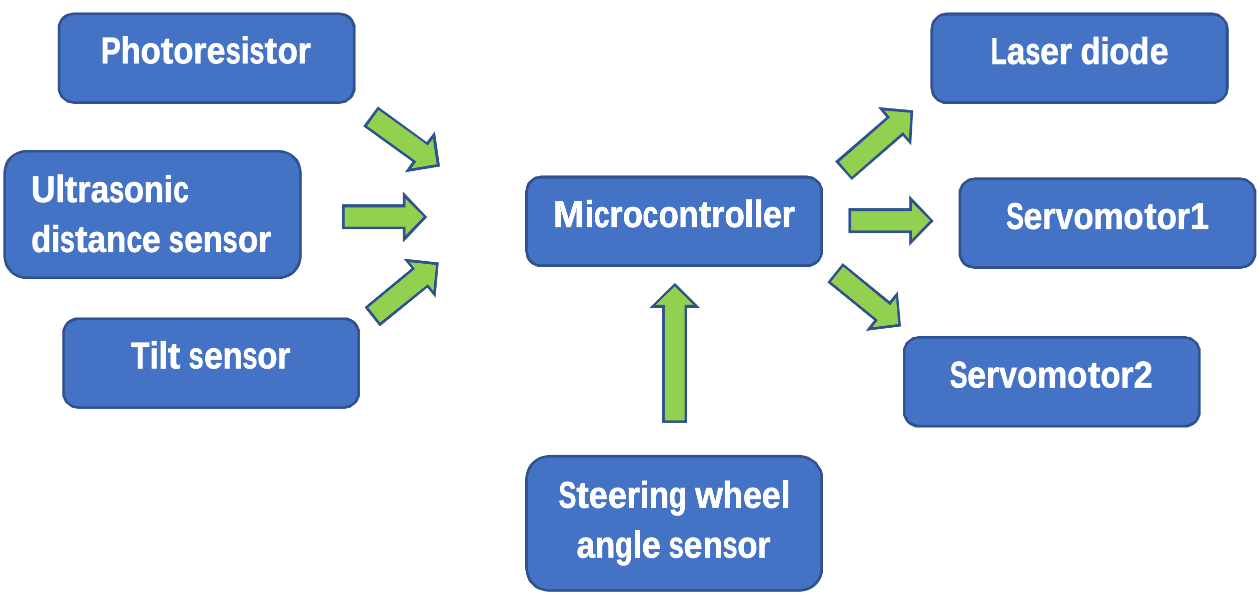

Figure 2: Block Diagram

V. INTERFACING CIRCUIT DIAGRAM

The circuit consists of an Arduino based on microcontroller Atmega 328p, a bulb representing laser diode, two servo motors, photoresistor for measuring intensity of oncoming traffic lights, a tilt sensor to recognize if vehicle is leaned or tilted on a banked road, potentiometer replicating steering angle sensor and an ultrasonic distance sensor to measure the distance of forward traffic.

For the tilt sensor, the terminal 1 is connected to the 5v pin of the Arduino and terminal2 is connected to ground through a 200 ohm resistor, also it is connected to the digital pin D12 of the Arduino.

For the photoresistor, the terminal 1 is connected to the 5v pin of the Arduino and terminal2 is connected to ground through a 1 kohm resistor, also it is connected to the analog pin A1 of the Arduino.

For the potentiometer the wiper is connected to the analog pin A0 of the Arduino. The terminal1 and terminal2 are connected to the ground pin and 5v pin of the arduino respectively.

For the bulb, the terminal2 is connected to digital pin D13 of the arduino and also its connected to the digital pin D11 through a 1kohm resistor.

For the ultrasonic distance sensor, the signal pin is connected to digital pin D4. The power and ground pins are connected to 5v and ground pins of the arduino.

For the servo motor for angular displacement, the signal pin is attached to the digital pin D2 and pwer and ground pins are attached to 5v and ground pins respectively.

For the servo motor for side direction, the signal pin is attached to the digital pin D3 and pwer and ground pins are attached to 5v and ground pins respectively.

VI. WORKING OF SYSTEM

Assuming that the lights are on and attached to the servo motors, when the driver steers at a corner or take a turn, the steering angle sensor senses the angle of turn and sends a signal to the microcontroller. The microcontroller then passes information to the servo motor 1 (for side direction) and actautes it in the direction of steering wheel.

If the driver is on a banked road the tilt ange senses the tilt and passes the signal to the microcontroller. The microcontroller actuates the servo motor 2 (for angular displacement) at a 30 degrees of angle.

The potential hazards due to the glare from oncoming traffic can be prevented by using photoresistor and ultrasonic distance sensor. The photoresistor measures the intensity of oncoming lights and ultrasonic distance sensor detects the distance between oncoming traffic and forward traffic as well. Together these sensors send information to the microcontroller and microcontroller sets the intensity of light from high to low and vice versa.

VII. SPECIFICATIONS OF SENSORS AND ATUATORS

A. ATmega328p Microcontroller

ATmega328 is an AVR microcontroller manufactured by Microchip. It follows RISC Architecture and processes up to 8 bits of data. It has a flash type program memory which can store data up to 32KB. With a clock speed of 16MHz, it works on 5v though the recommended voltage is 7v to 12v.

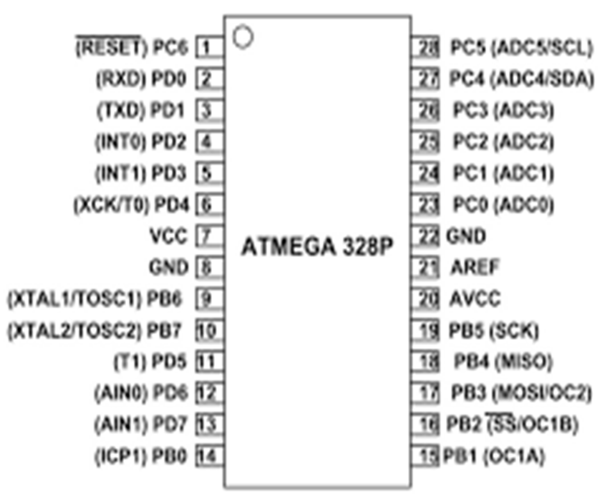

Figure 3: Microcontroller

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B. PING Ultrasonic Distance Sensor

The sensor works on 5v supply. It can measure precise non contact distance ranging from 2cm to 3m.

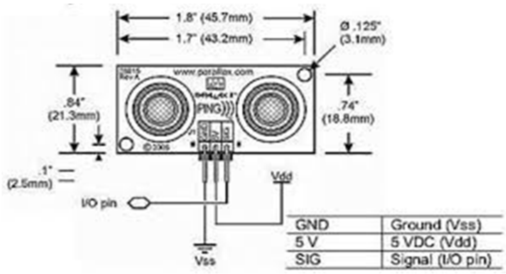

Figure 4: Ultrasonic Distance Sensor

C. Servo motor SG-90

The motor operates on 5v or more. It can roatate upto 180 degrees and has operating speed of 0.1s/60°. The torque provided is 2.5 kg/cm.

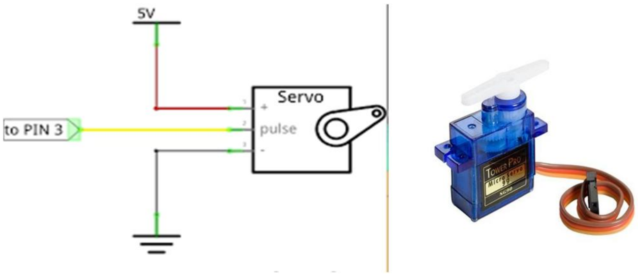

Figure 5: Servo Motor

D. Photoresistor GL5516

Photoresistor is a semiconductor device which can change its resistornce upon luminance. Photoresistor GL5516 can work with max voltage of 150v DC and environmental temperatures ranging from -40 to 70 degrees celcius. Light resistance at 10 Lux is 5 to 10 kohm and dark resistance is 0.5 mohm.

Figure 6: Photoresistor

E. Tilt sensor

Tilt sensor operates on supplying voltage of 3.3v to 5v. maximum opertaing temperature is 0°C to + 80°C. it gives output current upto 15mv.

Figure 7: Tilt angle sensor

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F. *Blue Laser Diodes 1.6W*

These diodes can emmit wavelength of 450nm. Their operating temperature ranges between -20 to 70 degrees celcius. Under normal conditions maximum current needed is 1.6A.

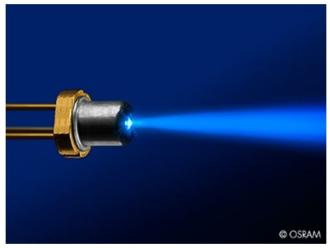

Figure 8: Laser diode

G. *Steering angle sensor:*

The sensor can measure the steering angle by ± 780°. The angular speed is 0 to 1,016°/s. the operating temperature needed is -40 to 85 degrees celcius. Operating voltage ranges from 7v to 12v.

Figure 9: Steering angle sensor

VIII. SOFTWARE DESIGN

```
#include <Servo.h>

Servo s1,s2;
int value;
double angle;
int light = 0;
int tilt = 0;
int direction =0;


void setup()
{
  Serial.begin(9600);
  s1.attach(3); //left/right swivelling servomotor
  s2.attach(2);//up/down swivelling servomotor
  pinMode(4, INPUT);
  pinMode(12,INPUT); //tilt angle sensor
  pinMode(13, OUTPUT);//Laser diode
  pinMode(11, OUTPUT);//Laser diode for dimming
  s1.write(90);//the motor will stay upright at 90 degrees
  s2.write(0);//at 0 degree, the lights are facing the road


}

void loop()
{
 //read the value of steering angle sensor

  value = analogRead(A0);//input of steering angle sensor
  angle = map(value, 0, 1023, 0, 180);
```


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```
  s1.write(angle);//rotate the servo motor for side direction
  //with steering
  delay(15);


 //read the tilt angle sensor

  tilt = digitalRead(12);
  if(tilt == HIGH)//vehicle is tilted
  {
  s2.write(30);//actuate servo motor for angulat displacement
    //at 30 degrees
  }
  else
  s2.write(0);

  //read ultrasonic distance sensor

  long duration;
  long cm;

  light = analogRead(A1);//potentiometer input

  //The PING)))is triggered by a HIGH pulse or 2 or more microseconds.
  //give a short low pulse beforhand to ensure a clean HIGH pulse
  pinMode(4,OUTPUT);
  digitalWrite(4, LOW);
  delayMicroseconds(2);
  digitalWrite(4, HIGH);
  delayMicroseconds(5);
  digitalWrite(4, LOW);
  duration = pulseIn(4, HIGH);


   // convert the time into a distance
    cm = microsecondsToCentimeters(duration);


if(light<=30 && cm>200)//oncoming light<30 & distance>200
  {

     digitalWrite(13,HIGH);//high beam

  }
  else if(light>30 && cm<=200)// oncoming light>30 & distance<200
  {
     digitalWrite(13,LOW);//turn down high intensity beam
    digitalWrite(11,HIGH);//low intensity beam
  }
   else if(light>30 && cm>200)// oncoming light>30 & distance>200
  {
     digitalWrite(13,HIGH);//high intensity beam

  }
    else if(light<=30 && cm<=200)//oncoming light<30 & distance<200
  {
    digitalWrite(13,HIGH);//high intensity beam

  }
   delay(1000);
   // Print the distance

  }

long microsecondsToCentimeters(long microseconds) {
    return microseconds / 29 / 2;
  }
```

Serial Monitor

Figure 10: Software design

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IX. PROGRAM FLOW CHART

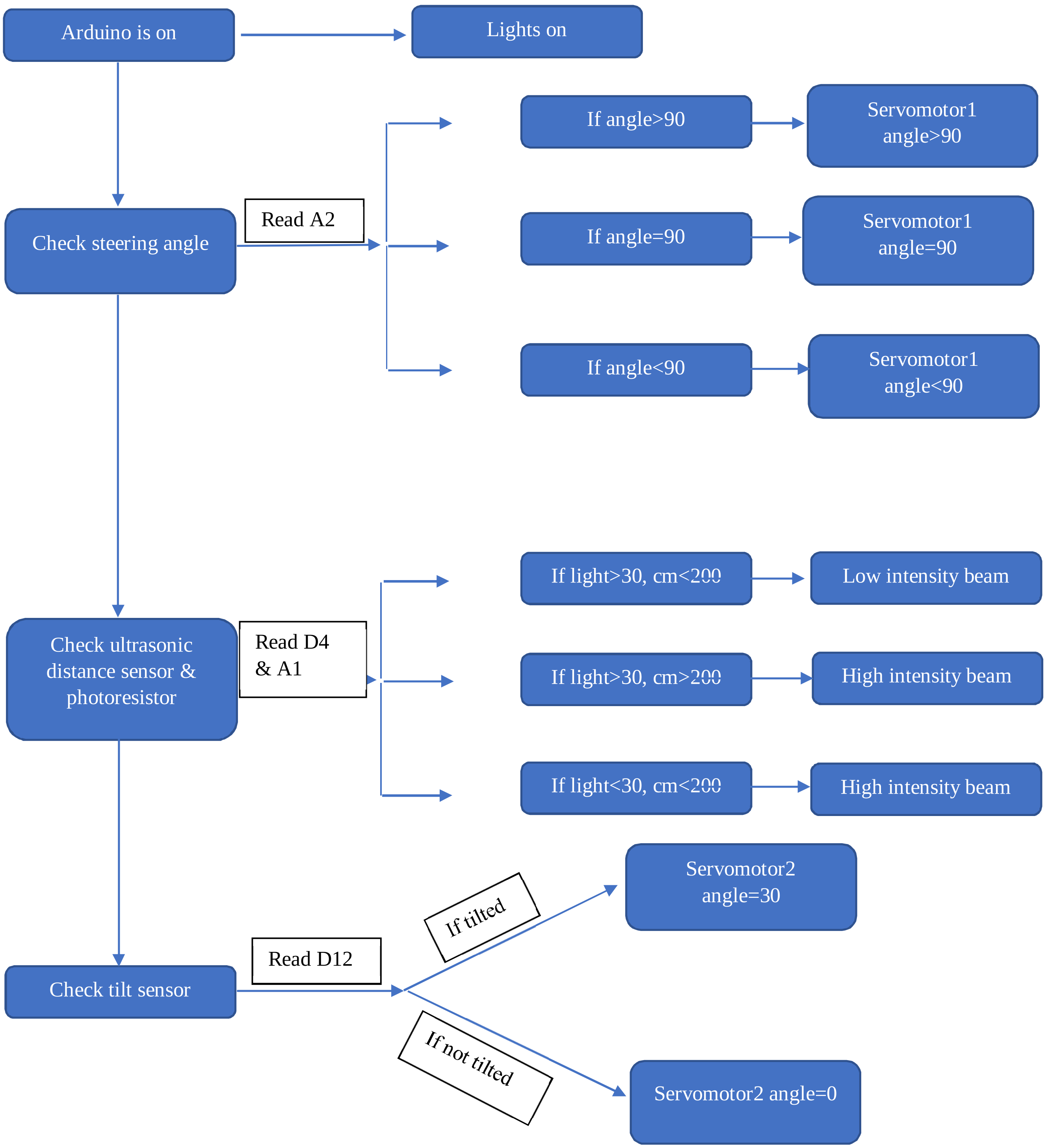

Figure 11: Flow Chart

X. RESULT & CONCLUSION

The proposed system works fine under normal conditions. The system is responsive with negligible time difference. The light dims and brightens as the ultrasonic sensor and photoresistor give inputs. The movement of servomotors is found satisfactory with the inputs of steering wheel angle sensor and tilt sensor.

The system can be effectively used in automobiles concerning safety parameters. The laser lights can illuminate the road far ahead without glaring the oncoming traffic. The system can be modified for further changes. It is a reliable and highly assistive system. This system can help avoid many fatal accidents.

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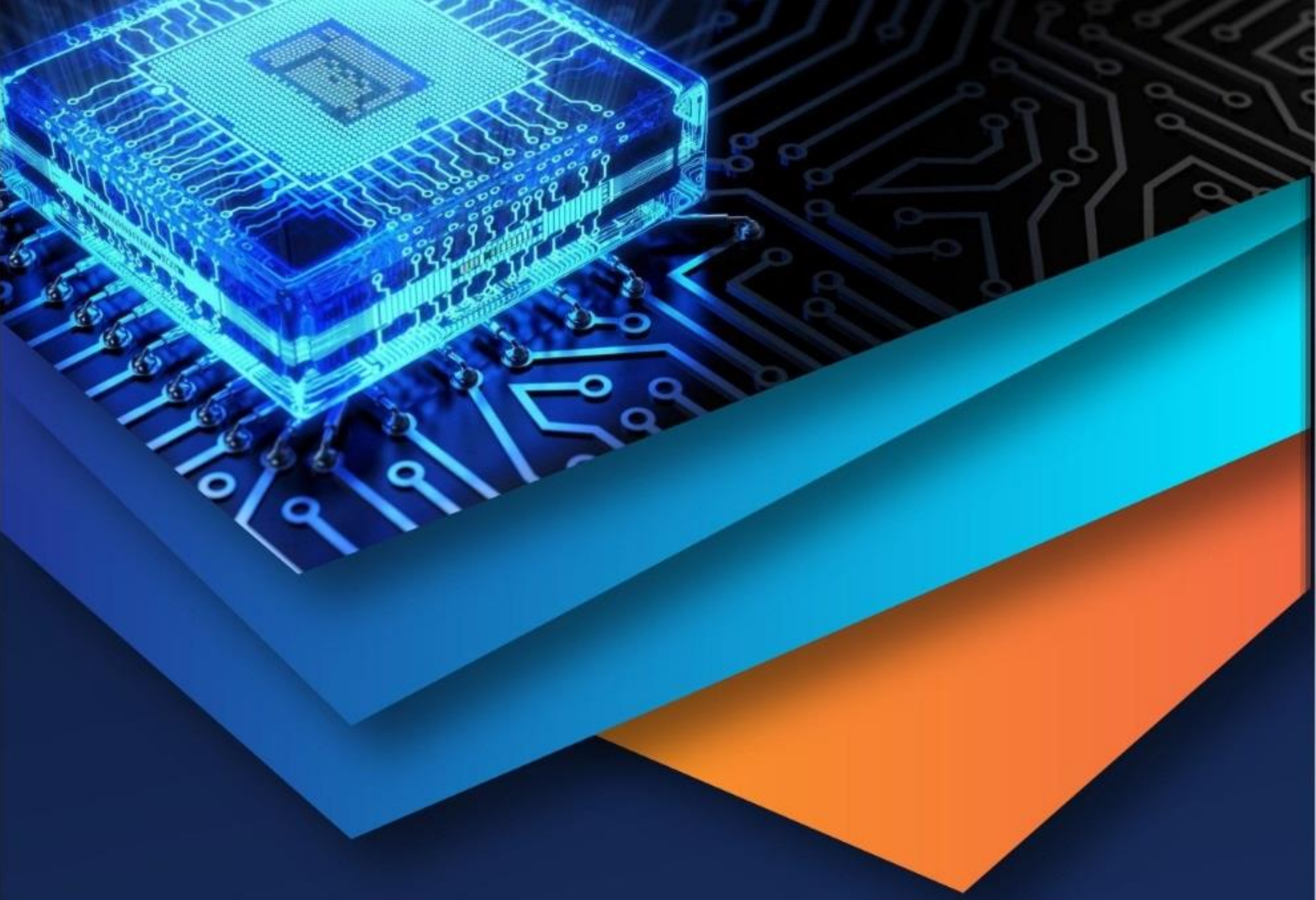

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