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Adaptive Headlight System for Automobiles

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***Abstract* - According to traffic accident data, the majority of severe road accidents occur at night. Therefore, it is of great importance to use available technology to contribute to road safety by improving the visual conditions provided by vehicle headlights. This paper presents the hardware in the loop simulation of an Adaptive Headlight System for motor vehicles. The Adaptive Headlight System is an active safety system, where the head lamp orientation control system rotates the right and left low beam headlights independently and keeps the beam as parallel to the curved road as possible to provide better night time visibility.**

I. INTRODUCTION

Accidents occur mostly at night rather than in day light. For avoiding the accidents adaptive headlights concept is very useful for automobiles. The focus on the subject of safety of car is related to the statics and to the expose the serious consequences of accident in 2014 out of 6,98,451 people from accident 4,882 people dead and remaining people were injured with a corresponding financial loss in India. In adaptive headlight system, the movement of headlight is synchronized with the movement of steering angle. This places light into the turning radius visibility. The present invention relates to headlights of an automobile, more particularly to a direction turning device for headlamps of the vehicle which enables to turn direction synchronously with the rotation of the steering and hence safety for night driving increases.

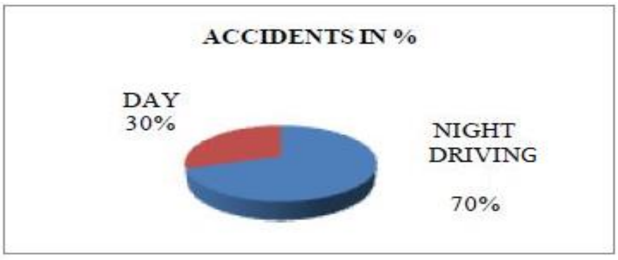

Fig 1. Accidents Statistics

II. FEATURES OF ADAPTIVE HEADLIGHT SYSTEM

A. First Feature – Horizontal Swiveling (Yawing Of Headlight)

Horizontal Swiveling is used to turn the headlight in horizontal plane. Headlight rotates in the direction proportionate to the wheel while taking turn.

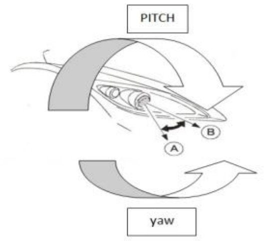

Fig 2. Yawing and Pitching

B. Second Feature – Vertical Swiveling (pitching of headlight)

Vertical Swiveling is used to compensate the pitching of car during driving through steep slope. It helps to focus the light at the required path.

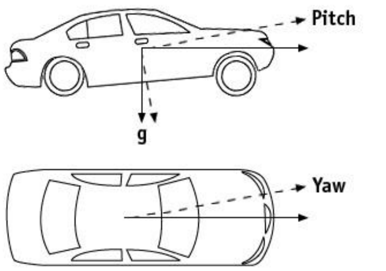

Fig 3. pitching of headlight

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III. DESIGN AND MANUFACTURING OF ADAPTIVE HEADLIGHT SYSTEM

Various mechanical components of adaptive headlight system were designed using PTC-CREO software package and reference geometry of standard car dimensions were used as a base for designing the setup of Adaptive headlight system.

A. Components of Adaptive headlight system

Mechanical components of Adaptive headlight system are-

1. Main Frame
2. Rack housing
3. Wheel U Clamp (2nos.)
4. Frame U Clamp (2 nos.)
5. Pitching Frame
6. Yawing Frame
7. Steering column
8. Wheel (2nos.)

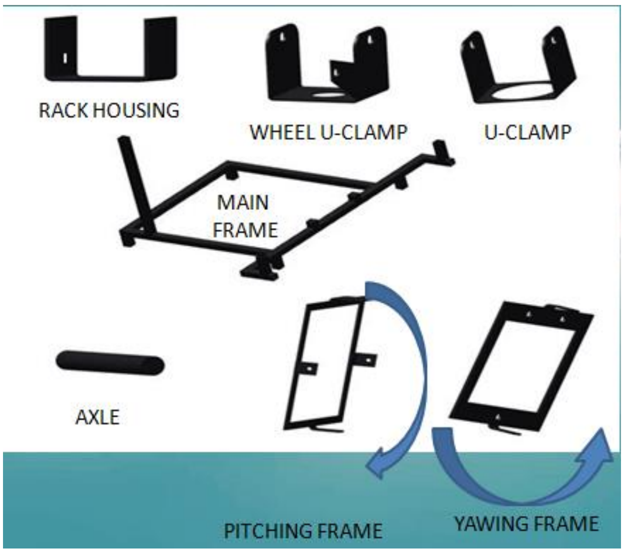

Fig 4. Components of Adaptive headlight system

B. Designing of components.

- *Main Frame, Wheel-u-clamp, Frame-u-clamp*

We used standard car dimensions to design our mainframe which works as support for steering column, pitching and yawing frames, electronic sensors.

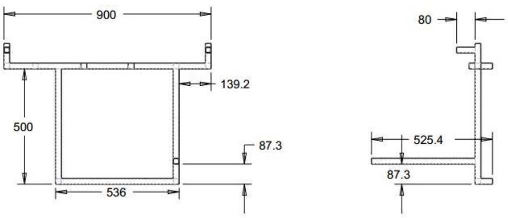

Fig 5 . Main Frame

Wheel- u-clamp and Frame- u -clamp are designed according to wheel dimensions and form a part of wheel actuating motion.

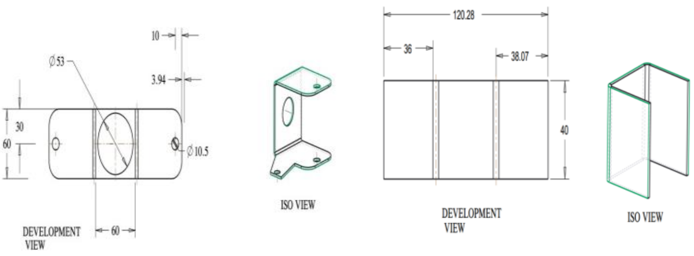

Fig 6. Wheel- u-clamp and Frame- u -clamp

- *Pitching and yawing frame*

Pitching frame and yawing frame dimensions are crucial as the two features of adaptive headlight system depend on accurate movements of these frames. we have taken several trial on CREO simulation for smooth working of frames.

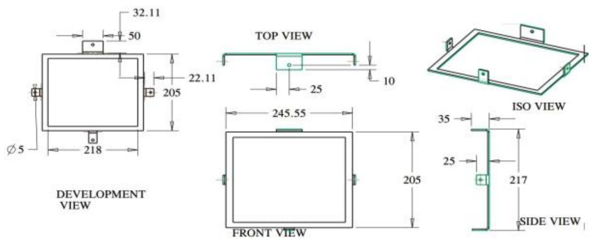

Fig 7. Pitching frame

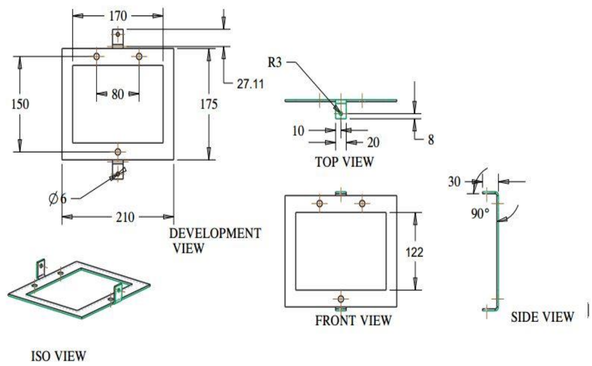

Fig 8. Yawing frame

C. Manufacturing of components

First we manufactured basic main frame using MS Square Pipe. We then mounted the standard Maruti-800 steering column and rack on rack housing on main frame. To fit steering wheel, steering column we used ball bearings. Then we welded caster wheels on wheel-u-clamp.

Main Frame

- **Dimensions**- 900 x 575 x 450 mm^2
- **Material**- M.S (25 x 25 mm^2)
- **Manufacturing processes-**
  - ➢ Saw-cutting
  - ➢ Electric-arc Welding(230 V)

Pitching frame

- **Dimensions- 250 x 200 mm^2**
- **Material- M.S**
- **Manufacturing processes-**
  - ➢ **Laser-cutting**
  - ➢ **Bending**

Yawing frame

- **Dimensions- 210 x 175 mm^2**
- **Material- M.S**
- **Manufacturing processes-**
  - ➢ **Laser-cutting**
  - ➢ **Bending**

Rack Housing

- **Dimensions- 45 x 40 mm^2**
- **Material- M.S**
- **Manufacturing processes-**
  - ➢ **Saw-cutting**
  - ➢ **Bending**

Wheel U-Clamp

- **Dimensions- 45 x 40 mm^2**
- **Material- M.S**
- **Manufacturing processes-**
  - ➢ **Laser-cutting**
  - ➢ **Bending**
  - ➢ **Drilling**

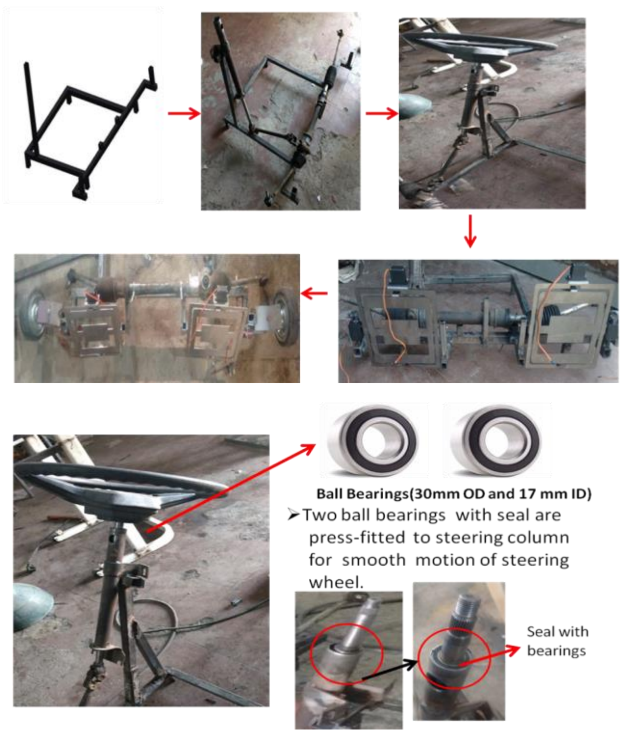

Fig 9. Manufacturing Stages

D. Lock to Lock angle and Steering Ratio

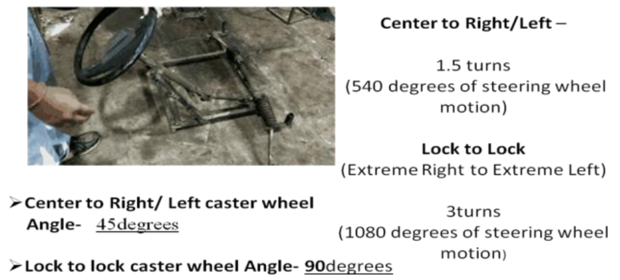

Fig 10 . Lock to Lock angle

- ➢ The steering wheel has to rotate THREE complete revolutions to move the caster wheel from lock-to-lock position .
- ➢ Thus 3 x 360 = 1080 degrees to move from lock-to-lock position
- ➢ Thus 1.5 x 360 = 540 degrees to move from Center to Right/ Left position
- ➢ Center to Right/ Left caster wheel Angle- 45 degrees
- ➢ Therefore,

$$\text{steering ratio} = \frac{\text{Angle moved by steering wheel (degrees)}}{\text{Angle moved by Caster wheel (degrees)}}$$

- ➢ S.R = 540/45 = 12= approximate 12:1
- ❖ Specifications of rack and pinion assembly –
- ➢ Number of teeth on rack = 27
- ➢ Number of teeth on pinion = 18
- ➢ Module = 1.5 mm
- ➢ Pressure angle = 20degrees
- ➢ Rack length = 127mm

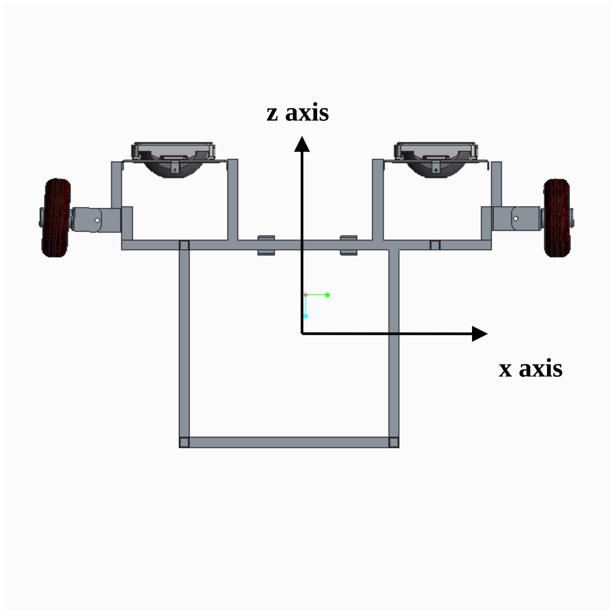

Fig 11 . Direction designation

IV. Electronic System

A. Blocks of electronic system

1. *Sensor Block* – This block consist of two sensors ultrasonic sensor and accelerometer sensor. These sensors act as input to the controller (Arduino Uno). The ultrasonic sensor is used to sense the linear motion, we have used HC-SR04 ultrasonic sensor it works on 5V power supply .The accelerometer is used to sense the inclination or tilt of the vehicle in along Z-axis, we have used ADXL335 accelerometer sensor it works on 5V power supply.

2. *Controller Block* – We have used Arduino Uno board for controlling the actuators and processing the data given by the two sensors. It works on 5volt power supply; it has 14 digital input output pins and 6 analog input pins.

3. *Actuator Block* – The frames on which headlights are mounted are actuated by servo motor shaft. We have used four servo motors to actuate the vertical and horizontal frames, each servo works on 5V power supply.

Fig 12. (a)Ultrasonic sensor (b) Accelerometer sensor

Parameter	Stepper Motor	Servo Motor
Drive circuit	Simple. The user can fabricate it.	Since the design is very complicated, it is not possible to fabricate your own driving circuit.
Out-of-step condition	Will not run if too heavy load is applied	Will rotate even if heavier load is applied
Control method	Open loop	Closed loop
Noise and vibration	Significant noise	Very little or no sound

Hence from the above table we conclude that servo motor is most suitable as it has to work with load while positioning the yawing frame and pitching frame as it is closed loop it helps in accurate position control

Over View of the physical structure of Adaptive Headlight System

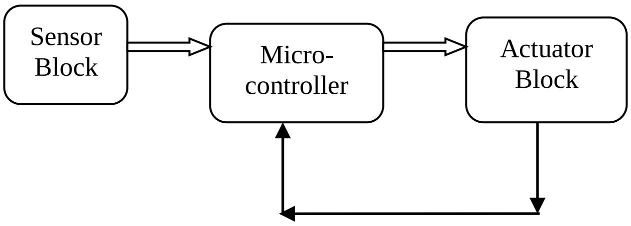

Fig 13. physical structure of Adaptive Headlight System

B. Principle of Operation

It is divided into two parts -

1. Horizontal Swiveling Control
2. Vertical Swiveling Control

1. Horizontal Swivel control (Yawing)

In our project we have used ultrasonic sensor to sense the horizontal motion, thus the sensor is used for control of yawing frame. The ultrasonic sensor sends the ultrasonic pulse from the trigger pin and after colliding with the obstacle it falls on echo pin thus trigger pin act as input and echo pin act as output pin, the distance is calculated by formula as –

$$\text{Distance} = (\text{speed of sound} * \text{time taken}) / (2).$$

The readings are sent to the Arduino after its set delay, the readings are analyzed by the controller and the required signal is sent to the servo motor. The servo motor synchronizes the yawing frame with the position of the caster wheels.

The set limits in program are -

- Distance greater than 17 cm rotates the yawing frame to extreme right.
- Distance between 15 and 17 cm give centred position of yawing frame.
- Distance less than 15 cm rotates the yawing frame to extreme left.

Fig 14. Yaw right

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Fig 15. Yaw left

2. Vertical Swiveling Control (Pitching)

In our project we have used capacitive type ADXL335 accelerometer to measure the inclination of the vehicle in XZ plane .It gives analog input to the ardunio, the micro-controller analyses the data and gives the required signal to the servo motor .These servo motors are used to align the pitching frame with respect to that of the tilt .When the tilt is in upwards the servo motor should move the pitching frame down and vice versa.

The set limits in program are –

- If position greater than or equal to 370 position the pitching motor in upward position by 20 degrees
- If position between 320 and 370 position the pitching motor in centre position
- If position less than or equal to 320 position the pitching motor in downwards position by 20 degrees

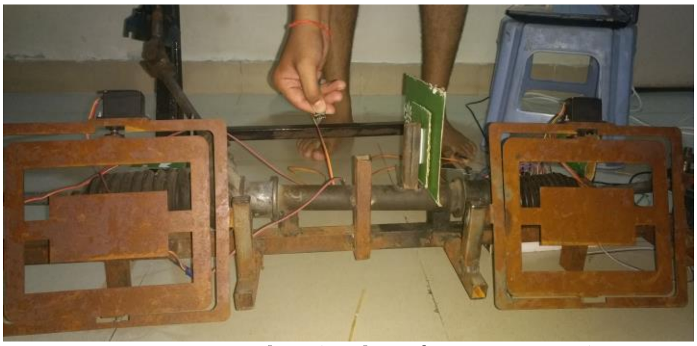

Fig 16. Pitch up(pitching frame moves up)

Fig 17. Pitch down(pitching frame moves down)

Fig 18. Centre position(pitching frame moves to center)

We have used zero PCB for supplying power to four servo motors through 5V 2 ampere Ac to Dc Adapter.

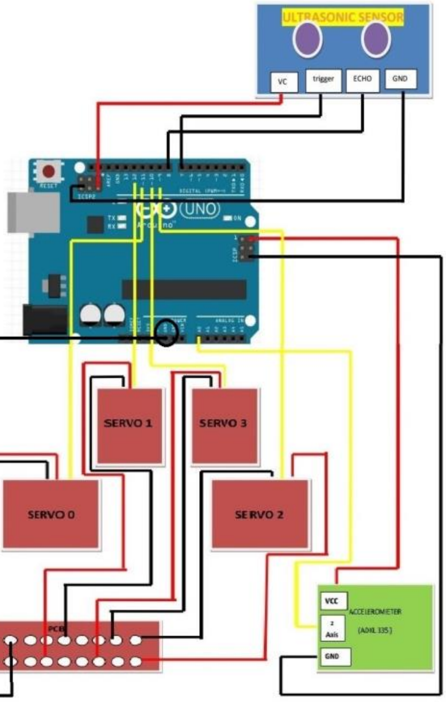

Fig 19. Circuit Diagram of adaptive headlight system

Adaptive_code_Integration §

```
if ((distance < 17) && (distance > 15))
{
  Serial.println("In center motor");
  myservo1.write(100);
  myservo3.write(100);
  delay(15);

}
else if (distance >= 17)
{
  Serial.println("In right motor");
  myservo1.write(120);              // tell servo to go to position in variable 'pos'
  myservo3.write(135);
  delay(15);                        // waits 15ms for the servo to reach the position
}
else if (distance <= 15)
{
  Serial.println("In left motor");
  myservo1.write(45);               // tell servo to go to position in variable 'pos'
  myservo3.write(60);
 delay(15);
}
}
```

Fig 20. Yawing Program

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```
Adaptive_code_Integration
  Serial.print("\t");
  delay(1000);
}

void servo_run()
{
  if ((adxl_y_val > 320) && (adxl_y_val < 370))
  {
    Serial.println("In centre motor");
    myservo.write(90);
    myservo2.write(90);
    delay(15);
  }
  else if (adxl_y_val >= 370)
  {
    Serial.println("In up motor");
    myservo.write(70);
    myservo2.write(110);
    delay(15);
  }
  else if (adxl_y_val <= 320)
  {
    Serial.println("In dowm motor");
    myservo.write(110);
    myservo2.write(70);
    delay(15);
  }
```

Fig 21. Pitching Program

V. RESULTS

We experimented on the accuracy of Pitching and yawing angle of headlight frame to achieve higher comfort and convenient working of adaptive headlight system.

A. Yawing frame angle

SR . NO.	Theoretical value of outside lock angle in degrees	Experiment value of outside lock angle in degrees	Accuracy percentage
1	29.5	27	91.525%
2	29.5	26	
3	29.5	28	

SR. NO.	Theoretical value of inside lock angle in degrees	Experiment Value of inside lock angle in degrees	Accuracy percentage
1	45	41	91.111%
2	45	43	
3	45	39	

B. Pitching frame angle

SR. NO.	Actual value in degrees	Experiment Value in degrees	Accuracy
1	20	18	88.33%
2	20	16	
3	20	19	

VI. CONCLUSIONS

Considering functionality, adaptability, accuracy of adaptive headlight system-

- Objective of headlight motion according to vehicle dynamics (Pitching and Yawing of headlight) is achieved by mechanical and electronic coupling of Arduino UNO, ultrasonic sensor, accelerometer(ADXL 335) .
- The level of accuracy is optimized using several experimental tests for user comfort and convenience.
- It is concluded that with Adaptive headlight system, the number of night accidents will reduce reasonably and that the reaction time or response time of the system in range of milliseconds (15 to 30).

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