Design of Automatic Headlight System Based on Road Contour and Beam from Other Headlights

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Design of Automatic Headlight Based on Road Contour and Other Headlight Light

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***Abstract*—Accidents often occur at night due to a lack of light. With the low-light conditions, a lot of drivers who use high beam headlight forgot to switch to low beam headlight. That action can cause temporary blindness to the driver in front of him because of the glare. Automatic Headlight can change the mode of lights and reflector lights when passing move uphill or downhill roads using the accelerometer sensor MPU6050. The automatic headlight can also change the mode of light based on the light in front of him using the BH1750 lux meter sensor so that the path illuminated by the headlight to be quite and do not endanger other drivers. Laboratory testing has a success rate of 97%, with 260 trials in 13 conditions. And on real testing, the automatic headlight can switch modes automatically when going uphill and downhill. The headlight can change modes automatically when passing through roads with adequate lighting or when passing other vehicles.**

***Index Terms*—Automatic Headlight, MPU6050 Accelerometer, Luxmeter BH1750**

I. Introduction

Car ownership in the last two decades has spread rapidly at every level of society, so safety in driving is a significant concern. Some of the factors that cause traffic accidents are humans, vehicles, roads, and the environment. Vehicle factors contributed 2.76% in traffic accidents in Indonesia [1]. Most accidents occur at night, especially if there is no street lighting on the road [2]. The misuse of high beam lights causes some accidents that occur at night [3]. When faced with the other vehicles, drivers forbidden to turn on the high beam lights because when the vehicle meets each other, another driver who receives the high beam light dazzled and can experience momentary blindness that can cause accidents. Many of the drivers forget to change the vehicle's beam headlight mode when passing on dark uphill or downhill roads. The habit of not changing the headlight mode is dangerous for other drivers and the driver himself. For that, we need a system that can change the car's headlight mode automatically. The entry of electronic devices into motorized vehicle systems has changed the direction of development and innovation in vehicles. The technology we call the smart car, which is a car that combines electrical, electronic, and communication technology [4] - [5]. Smart car development aims to improve the safety and comfort of vehicle users.

II. Related Works

Previous research has designed a car that can detect the condition of the road surface [6] - [7]. The research uses the Inertial Measurement Unit (IMU), which utilizes an accelerometer and gyroscope to measure the road surface. Other studies have discussed methods for controlling headlight by adjusting the speed and tilt of the vehicle [8]. Other research also discusses how to detect other vehicles at night using cameras and image processing methods [9]. Similar research also discusses how to identify other vehicles using a camera with a curb line as a reference [10]. The disadvantages of these studies are not suitable for use in the way that there is no curb line. Most of the previous studies used the camera as the main component to detect the presence of other vehicles. The use of the camera as the main component is less efficient when viewed from a financial perspective. Besides, the use of image processing techniques is also considered less efficient in terms of computing, if only to replace the headlight.

This study uses the BH1750 module as the main component to detect other vehicles facing in front of it. This study also used the MPU6050 module to assess road contours. That way, the Headlight not only changes the automatic mode based on the presence of other vehicles but can also change when passing the uphill or downhill road. So we need a system that can reduce the direction of the headlight beam when passing through the uphill road, can increase the course of the headlight beam when the road is down, and automatic light modes that can be automatically changed when facing other vehicles. When passing the road uphill, the vehicle load point will be centered on the rear. Conversely, the car's load point on the downhill road will be focused on the front so that the back of the vehicle rises and causes the Headlight beam to be closer. This condition causes the front of the car to lift. So that the headlight beam goes up and does not illuminate the road properly can even cause other drivers to glare.

III. Proposed Method

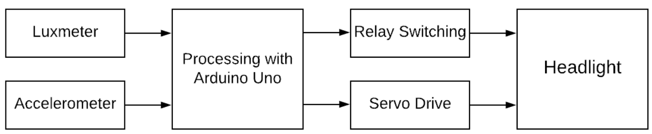

Fig. 1. Block diagram of the system

This research design and create automatic headlight based contours of the road and other Headlight lights. The block diagram in Fig. 1 shows the whole system consists of several series of blocks, namely the BH1750 lux meter sensor as a receiver of light coming from the front and the MPU6050 accelerometer sensor used to assess the slope of the road. Both of these sensors function as input, which will be processed by Arduino Uno. Relay Switching to change the lamp mode from high beam headlight to low beam or vice versa. A driving servo to change the direction of the lamp reflector so that the beam direction can be up or down. Changes in lamp reflectors and servo motors depend on the process carried out by Arduino Uno. The headlight on the block diagram as the primary output in the system.

Automatic headlight system design flowchart using the lux meter sensor and accelerometer can be seen in Fig. 2. The input to this system is the angle of the road and the light of other vehicles. The slope of the road is measured using an accelerometer sensor. If the road slope measurement is greater than 5 degrees, the servo motor pushes the top of the reflector forward 1 degree and the headlight mode changes to low beam mode. If the slope of the road is less than 5 degrees, the servo motor pulls the top of the reflector backwards 2 degrees and the headlight mode changes to low beam mode. The servo will not move when the tilt angle is zero or pass a flat road. Measurement of light intensity using a Lux meter. If the light intensity received by the lux meter is more than 5 lux, the headlight mode will switch to the low beam mode and then finished.

IV. Result

Automatic headlight testing process takes place in the laboratory and actual conditions. Testing in the laboratory to ensure the system can run well before it is installed on the car. Research on a laboratory scale is carried out on a prototype of the front of a car made of wood board material. The prototype is made with the same dimensions as the actual conditions so that after laboratory testing, the components and machine tools can be directly transferred to the car. The prototype of the front of the vehicle has dimensions with a length of 40 cm; width 23.5 cm; and height 29 cm. Headlight system in the design of this tool is composed of several electronic

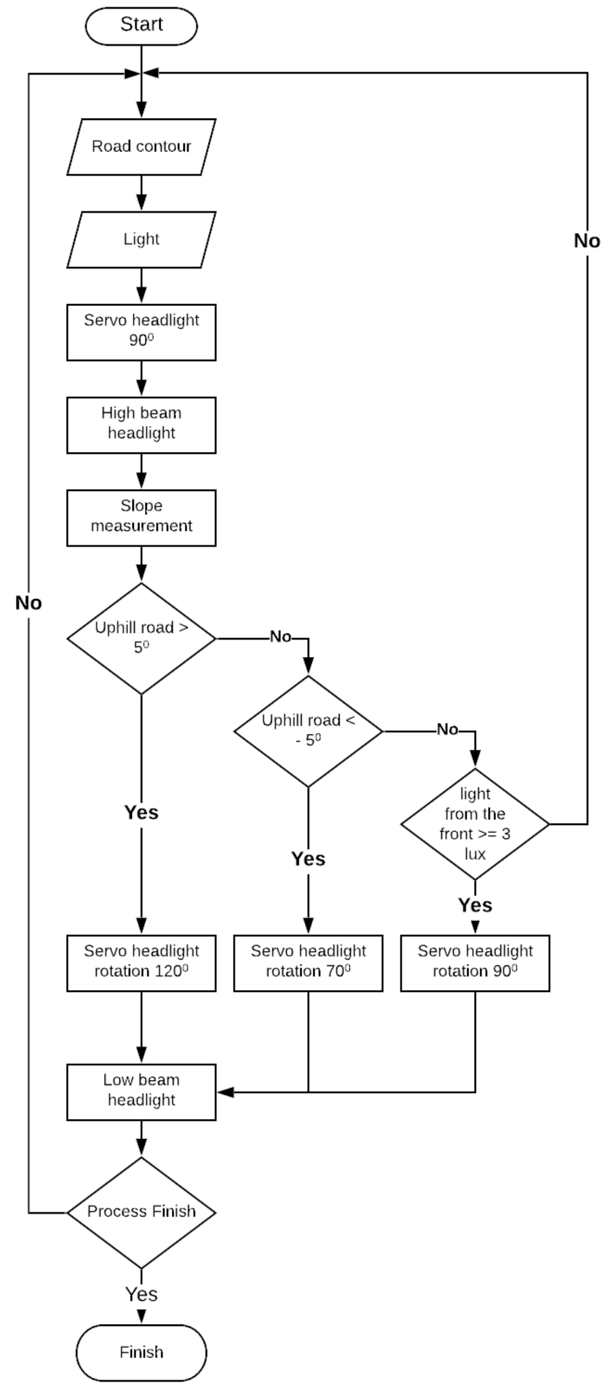

Fig. 2. Automatic headlight system design flowchart

instruments such as MPU6050, BH1750, Servo Motor. The Headlight system also consists of several mechanical parts such as a lamp driving lever, roll on a flexible bracket so that the bracket can be removed, and the bracket that can be moved so that the Headlight reflector can move.

In laboratory testing, the MPU6050 module as an accelerometer, the BH1750 module as a lux meter, MG995 Servo Motor movement testing and overall tool testing is tested. In accelerometer testing, the MPU6050 module is manually calibrated. Calibration is performed using a ruler bow and water pass. Arc ruler used to determine the amount of the angle measured by the sensor and water pass used to ensure calibration is done in a flat field. Testing is done by rotating the position of the sensor from the slope of 0 degrees to 90 degrees. So that the values obtained in Table I.

TABLE I
ACCELEROMETER SENSOR TESTING

No	Trial Angle	Raw Data Y	Y/16384	Measurement Angle	Difference Angle Measurement
1	0°	132	0,0081	0,4614°	0,4676°
2	5°	1540	0,0940	5,3934°	0,3934°
3	10°	2572	0,1570	9,0318°	0,9682°
4	15°	3562	0,2174	12,5568°	2,4432°
5	20°	5564	0,3396	19,8525°	0,1475°
6	25°	7016	0,4284	25,3548°	0,3548°
7	30°	8024	0,4897	29,3239°	0,6761°
8	35°	9288	0,5669	34,5340°	0,4660°
9	40°	10544	0,6436	40,0574°	0,0574°
10	45°	11520	0,7031	44,6783°	0,3217°
11	50°	12524	0,7644	49,8540°	0,1460°
12	55°	13280	0,8105	54,1494°	0,8506°
13	60°	14224	0,8682	60,2460°	0,2460°
14	65°	14924	0,9109	65,6284°	0,6284°
15	70°	15272	0,9321	68,7691°	1,2309°
16	75°	15772	0,9626	74,2904°	0,7094°
17	80°	16164	0,9866	80,6000°	0,6000°
18	85°	16216	0,9897	81,7879°	3,2121°
19	90°	16363	0,9987	87,0988°	2,9012°
Deviation					0,8850°

Table I shows the results of testing the accelerometer sensor up and down. The most significant error is 3.21 degrees at 85-degree angle measurements, and the smallest error is 0.06 degrees at 40-degree angle measurements. The average error in the sensor measurement is 0.8850 degrees.

Measurement of light intensity at the driver's place using a lux meter sensor. In this research, before the BH 1750 module is used in the system, the module is calibrated first by comparing it to other lux meter measuring devices. Testing is done in several different conditions. Tests carried out by measuring the intensity of light at a place with separate lux.

Table II shows the testing of the lux meter measuring device experienced a slight difference in the measurement of light intensity. The measurement value of the lux meter measuring instrument tends to be higher than the BH1750 measurement.

The next test is testing the movement of the Servo Motor MG995. Servo motor to adjust the direction of the reflector lights up and down. At first, the servo motor is in a normal

TABLE II
LUX METER MODULE TESTING

No	Calibration	Digital Lux Meter Measurement	BH1750 Measurement
1	Indoor (lights off)	0	0
2	Indoor (lights on)	66	54
3	5 watt flashlight	141	131
4	5 watt lamp	30	28
5	Laboratory	35	35

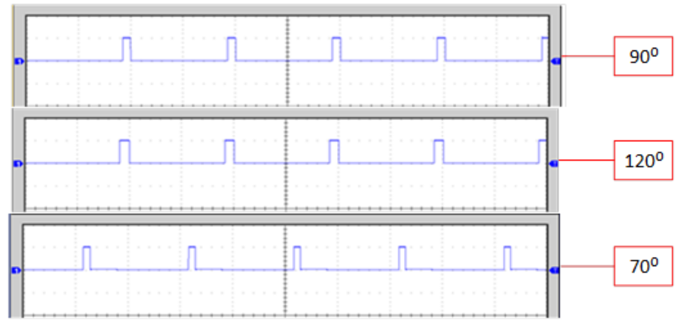

Fig. 3. PWM Servo Signal Forms

position, which is 90 degrees. Then the servo motor moves in the direction of 120 degrees when the road is uphill and in the direction of 70 degrees when the road is downhill. Oscilloscope signal readings on the servo motor are in Fig. 3. Testing using an oscilloscope aims to determine the waveforms of PWM signals generated by servo motor movements when the road conditions are uphill or downhill. The shape of the PWM signal (Fig. 3) has a different pulse width at each angle. The pulse width measurement for each test can be seen in Table 3.

TABLE III
SERVO PULSE WIDTH MEASUREMENT

No	Servo Motion Angle	High Pulse (ms)	Low Pulse (ms)	Period (ms)
1	90°	1,47	18,6	20
2	120°	1,78	18,2	20
3	70°	1,27	18,8	20

After calibrating the tool, the next step is testing in the laboratory. Laboratory testing is testing the whole system on a prototype to determine the level of success of the instrument. Before the tool is mounted on the car, the device is first installed on a one to one scale prototype. Prototype installation is done to ensure the mechanical and electrical systems can work as expected. Testing is done in two ways. First, the front of the prototype is raised until it reaches an angle of 3 degrees, 6 degrees, and 9 degrees, then continued on the back in the same way. Both prototypes are given a beam of light. The success rate of tool response in each test can be seen in Table IV. Laboratory tests carried out are 20 times for each condition. The working system of this tool has an average success rate of 97.3%. The headlight system that has been made successfully changes the light mode when it detects uphill, downhill, and when receiving light from the direction before it.

TABLE IV
LAB TESTING

No	Testing Tool	Form	Number of Experiments	Percentage of Success
1	Front Lifted	3^o	20	100
2	Back to Original Position 1	3^o	20	100
3	Rear Lifted	3^o	20	100
4	Back to Original Position 2	3^o	20	100
5	Front Lifted	6^o	20	100
6	Back to Original Position 1	6^o	20	80
7	Rear Lifted	6^o	20	100
8	Back to Original Position 2	6^o	20	85
9	Front Lifted	9^o	20	100
10	Back to Original Position 1	9^o	20	100
11	Rear Lifted	9^o	20	100
12	Back to Original Position 2	9^o	20	100
13	Beam Lights From the Front	12 Lux	20	100

TABLE V
ACTUAL TESTING

No	Testing	Road Measurement		Headlight Response	
		Tilt	Intensity	Headlight Mode	Headlight Position
1	Faced with another vehicle	$-0{,}15^o$	11 Lux	Low Beam	Not Change
2	Flat, Dark	$-0{,}15^o$	0 Lux	High Beam	Not Change
3	Flat, Bright	$0{,}15^o$	6 Lux	Low Beam	Not Change
4	Uphill, Dark	$7{,}19^o$	0 Lux	Low Beam	Down
5	Uphill, Bright	$7{,}19^o$	6 Lux	Low Beam	Down
6	Downhill, Dark	$-7{,}37^o$	0 Lux	Low Beam	Up
7	Downhill, Bright	$-7{,}37^o$	5 Lux	Low Beam	Up

After testing in the laboratory, the next step is to examine the actual conditions. The real test aims to find out whether the automatic Headlight control system can work according to the design that has been made from the beginning to the end of the car. Testing is done by considering two conditions. First, the vehicle passes the road with reduced street lighting levels and is sufficient with flat road conditions. Second, the car passes the road uphill and downhill with enough and less lighting to determine the response of the headlight. The results of the headlight response are in Table V. Based on the test results in Table V, the automatic headlight can switch modes automatically when going uphill and downhill. The headlight can change modes automatically when passing through roads with adequate lighting or when passing other vehicles.

CONCLUSION

Most accidents occur at night, especially if there is no street lighting on the road. The misuse of high beam lights causes some accidents that occur at night. For that, we need a system that can change the car's headlight mode automatically. This research design and create automatic headlight based contours of the road and other headlight lights. This study uses the BH1750 module as the main component to detect other vehicles facing in front of it. This study also used the MPU6050 module to assess road contours. That way, the Headlight not only changes the automatic mode based on the presence of other vehicles but can also change when passing the uphill or downhill road. Both of these sensors function as input, which will be processed by Arduino Uno. Relay Switching to change the lamp mode from high beam headlight to low beam or vice versa. A driving servo to change the direction of the lamp reflector so that the beam direction can be up or down.

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REFERENCES

[1] J. Anwar, "Traffic Safety Education and Information Campaign Activities in Indonesia," pp. 1–20, 2010.

[2] Plainis, S et al. "Road traffic casualties: understanding the night-time death toll." Injury prevention : journal of the International Society for Child and Adolescent Injury Prevention vol. 12,2 (2006): 125-8. doi:10.1136/ip.2005.011056

[3] Synák, František and Rievaj, Vladimír and Vrábel, Ján and Darko, Babic. (2018). EXAMINATION OF THE VEHICLE LIGHT INTENSITY IN TERMS OF ROAD TRAFFIC SAFETY: A CASE STUDY. 81. 119-128. 10.14669/AM.VOL81.ART10.

[4] S. Lee, So-Eun; Kim, "The Influence of Smart Car Technologies on Drivers' Perceived Control and Attachment," 2017.

[5] H. O. Al-sakran, "Intelligent Traffic Information System Based on Integration of Internet of Things and Agent Technology," Int. J. Adv. Comput. Sci. Appl., vol. 6, no. 2, pp. 37–43, 2015.

[6] J. Huang, Z. Huang and K. Chen, "Combining low-cost Inertial Measurement Unit (IMU) and deep learning algorithm for predicting vehicle attitude," 2017 IEEE Conference on Dependable and Secure Computing, Taipei, 2017, pp. 237-239.

[7] I. Krzysztofik, J. Takosoglu, and Z. Koruba, "Selected methods of control of the scanning and tracking gyroscope system mounted on a combat vehicle," Annu. Rev. Control, vol. 0, pp. 1–10, 2016.

[8] Y. S. Chen and S. C. Chiu, "New method of automatic control for vehicle Headlights," Optik (Stuttg)., vol. 157, pp. 718–723, 2018.

[9] P. Sevekar, "Night-time Vehicle Detection for Automatic Headlight Beam Control," vol. 157, no. 7, pp. 8–12, 2017.

[10] S. Eum and H. G. Jung, "Enhancing light blob detection for intelligent Headlight control using lane detection," IEEE Trans. Intell. Transp. Syst., vol. 14, no. 2, pp. 1003–1011, 2013.