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Optimal Lane Finder using Sensor Fusion Techniques to Prevent Road Accidents

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Abstract

Objectives: Most of the accidents could be avoided or prevented through simple measures like speed limit, precautions for the driver's safety and discipline among road users. Most of the accidents occur on highways, especially when changing lanes. This paper focuses on reducing such accidents by using Lane Keeping Assist System (LKAS). **Methods:** This LKAS is based on the concept of neural network model, which has a high complexity and high cost design for functional implementation. **Findings:** Though this system has more advantages, it cannot be implemented in all range of cars. In order to overcome this, a cost affordable, safety alert system suitable for all range of cars is proposed using low cost and low power consumption open source device, in which vehicles are incorporated with sensors which helps in notifying when the vehicle is overtake and makes it easier for people to control the movements of vehicle. **Application/Improvement:** It helps to indicate the unconditional changes of vehicle between the lanes and also reduce the accidents. Apart from this, fading and blinking of front head lights automated whenever approaching in opposite direction.

Keywords: Kalman Filtering, Sensor Fusion

1. Introduction

An accident results in a sudden change of speed when an object crash into another object. The impact of the accident depends on the direction and speed of both the colliding objects. If the objects are moving in the same direction, the collision will be more ferocious than moving in the same direction. Collision happens more widely in highways, especially while changing lanes. Safety precaution systems are deployed in the cars to assist the driver to drive in the same lane. LKAS which provides steering input to help keep the vehicle in the middle of a detected lane and alerts if the vehicle is detected drifting out of its lane while driving between (45-90 kmph). The alert is give visually near to the speedometer. If your vehicle is getting too close to the detected left or right side lane markings without a turn indication, the system provides visual and tactile alerts so that driver can see the markings of the lane by which he can proceed to it. Next is Adaptive Cruise Control (ACC) which is an intelligent machine form of control that slows and speeds the vehicle automatically to keep pace with the car in front of you and maintains the vehicle speed constantly with respect to the vehicles in front of it. Anti-Lock Braking System (ABS) which paves for the vehicle to maintain a firm contact with the road surface while braking, preventing the vehicle wheels from locking up and avoiding uncontrolled skidding on the road surface. Laser Light technology is one of the more recent headlight technologies; with a beam range double the normal headlights. In laser, the beams of light are bundled together to attain a luminous intensity 10 times greater than a normal headlight. This also avoids glaring to the vehicles approaching in the opposite direction by dimming a part of the headlight until approaching vehicle passes by. All systems which are controlled by Electronic Control Unit (ECU) react in terms of milli seconds (ms). The motivation of the intended system is to assist the drivers and help avoid crashes on the road, as well as alert them is prevented needless accidents. This helps the driver to have maximum usage of this sys-

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tem, customer acceptance and collision avoidance. To enhance the efficiency, the system is developed and tested on natural road. Neural network model is developed to guess the lane changing behaviour[1]. Side Blind Zone Alert (SBZA) helps driver avoid lane change crashes by warning them with the side mirror display, when a vehicle is detected in their blind zone. Warning may be given either through audio or physical disturbance[2]. Many researchers did not measure the speed of vehicles with respect to the lateral distance, for a new combination of risk factors is identified: Occupancy of lane and aerodynamic effect of vehicles overtaking one vehicle. Aerodynamic force is based on both lateral distance and speed of the vehicle. According to the aerodynamic force, speed of the vehicles in the target lane can be approximated by,

$$F = \tfrac{1}{2}\,\rho S V^2 C \qquad (1)$$

Where F-Lateral force, ρ- Air density. V-Speed of the overtaking vehicle. S- Front area of the overtaking vehicle. C- Dimensionless coefficient.

In order to overtake a vehicle, aerodynamic force is also considered as an input to the driver. In order to identify the vehicles position Global Positioning System 0(GPS), direction sensor and acceleration sensor are integrated to it. They always have an error; so to improve the positioning accuracy, Kalman filter is used to eliminate the noisy points and make the trajectory smoother. Finally, an optimal result is obtained[3]. Vehicle's steering adjustment is given as the input to the ECU which makes the decision for the lane change, in this they mark the mean steering wheel angle of the cars usually it is 2.5°. Steering wheel position is a straight computable vehicle parameter appears as an analyst of a lane change, the calculated model of the steering wheel position is stated, which contributes prediction of lane change movement[4]. Implementation of any safety precaution system with all possible demands is very costlier, and cannot affordable to all the vehicles, so to overcome all difficulties a cost effective safety precaution system is proposed[5]. This system which consists of sensor modules where they acquires values from the unoccupied lane and gives the suitable alert to the driver so that he/she can control the vehicle to avoid collision. To get the effective and regular noiseless values from the sensors, Kalman filtering technique is introduced to avoid the noise so that it tends to produce the accurate output. Overall proposed work is discussed in upcoming chapters.

2. Proposed System Architecture

This work concentrates on the safety lane changing mechanism using Arduino Mega which has 8-bit ATMEGA 2560 controller to it which acts as Electronic Controller Unit (ECU) for the process in addition to Anti-Headlight glaring. This system provides flexible driving during day and night time. In this method, ECU is developed which provides efficient suggestions and suitable decision making to the driver while changing lanes. The prototype model consists of MEMS sensor module i.e., ADXL 335 which measures the direction variation along the horizontal direction-Ultrasonic sensor i.e., HC-SR04 for object identification in the target lane and Light Dependent Resistor (LDR) for automatic headlights along with anti-glaring is proposed. Continuous data samples are taken from the prototype sensors for further analysis. The data samples from accelerometer and ultrasonic sensors obtained are subjected to the Kalman filtering process for removal of random variations. The filtered outputs of both sensors are fused for decision making and further processing. The proposed framework is shown in Figure 1.

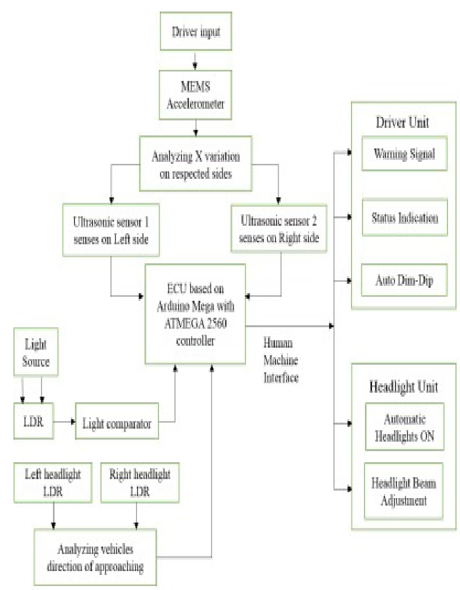

Figure 1. Block diagram for the proposed work.

2.1 Kalman Filtering Technique for Data Fusion

In order to have the effective values from the sensors, Kalman filtering technique is used to filter observed results from different sensors, which makes the decision making process efficacious. The data extracted from the sensors are given as inputs to the Kalman variables. For further processing of data, the series of inputs are taken and represented as x, after analysing of data, covariance for decision making is set to (-2.0 to 2.0) for X-variation and 1.8 metres(m) for object detection[6]. Values of x from both the sensors are taken for the noiseless of data. Extractions of values from the sensors are given as the input for Kalman process for the data fusion i.e., the values are substituted in Equation (2). The results of fusion are represented in the Table 1 which shows the variations between raw sensor data and normalised one.

Processed value, $Xe(t) = x(t) + K * (measurement(t) - H * x(t))$ (2)

Figure 2 represents the fusion process of two sensors used in this prototype. Hence the processed data is taken for further processing. Figure 3 represents the graph plotted for the sensor values and their responses are obtained before and after Kalman filtering process. The variations in the graph clearly portray the advantages of filtering process for decision making. With these results, ECU decides the need for the changeover of lane. If the target lane is occupied or populated then alert is given to the driver, else the signal for the lane change is given. After training and analysing, the fused data with respect to training samples is given to envisage the lane altering. Given the outputs, a threshold value must be determined, instead of choosing the random threshold value, Receiver Operator Characteristic (ROC) curve is drawn whose values are acquired by the series of threshold value and is shown in Figure 4. This shows that a minimum False Positive Rate (FPR) of 0.5 % is required in order to have the efficient response time[7]. According to the sample values of input and fused, Threshold value is set. When threshold value of X variation is more than 2.0 and less than -2.0, the driver is allowed to change lanes, if it is in between -2.0 to 2.0 it is intimated to the driver to stay in the same lane. By collecting various samples, the accuracy of the model is analysed and based on this, further processing is carried out and there are three possible scenarios. The complete hardware prototype model is described in Figure 5.

2.2 Case 1: When Main LDR Intensity is Normal

With respect to Table 1, filtered result of X-variation and filtered result of object detection are masked and compared with the covariance, if the difference more than threshold, then information is given to the driver unit for the process of lane change and when the driver changes lane, respective indicator light along with headlight passing is done.

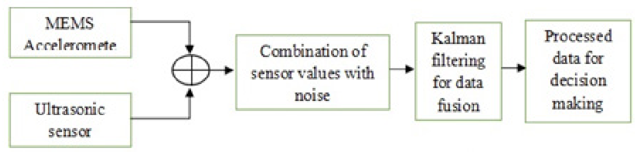

Figure 2. Sensor fusions for decision making process.

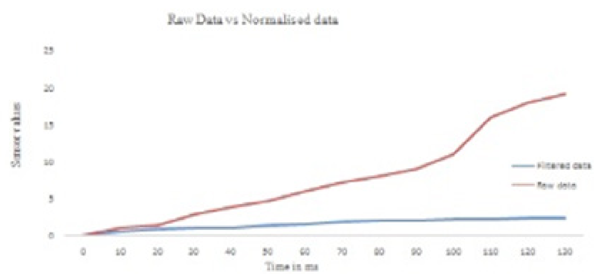

Figure 3. Raw data vs normalised data.

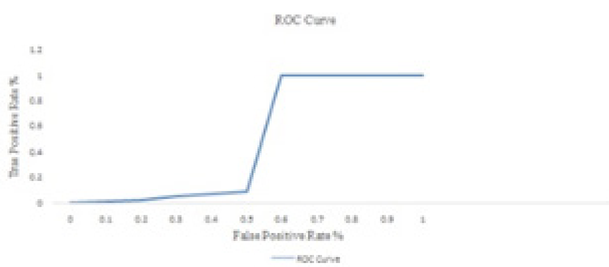

Figure 4. ROC curve.

2.3 Case 2: When main LDR Intensity is Low

Headlights are switched ON automatically then case 1 process is continued for further operation.

2.4 Case 3: Headlight Beams Adjustment

When vehicle approaches in opposite direction either in left or right, the appropriate headlights brightness are reduced and regained back to the brightness state after the approaching vehicle passed by[8].

3. Results

From the obtained data, the lane changing process and the suitable alert is given to the driver with the indication[9].

The fused data from the different sensors are deployed in this model, so whenever the lane change process is going to happen i.e., the variation along the horizontal direction, followed by detection of object by ultrasonic sensor in the target lane.

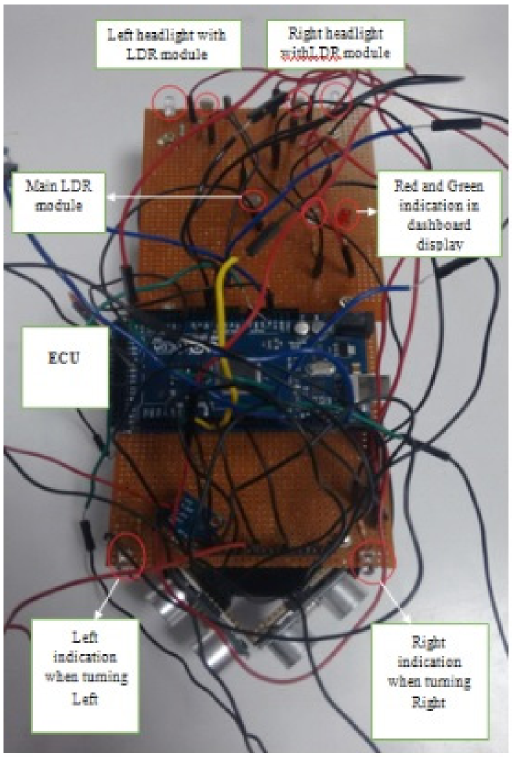

Figure 5. Hardware prototype.

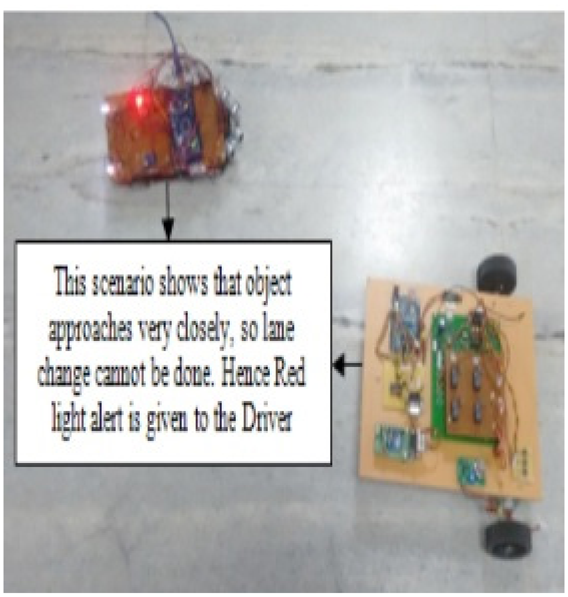

Figure 6. Red alert to driver about the object in the target lane.

Scenario1

The cautious alerts the driver when the object approaches the target lane. So when object approaches, Red LED glows, which shows that target lane is occupied by one vehicle is shown in Figure 6.

Scenario 2

Green alerts the driver when the object is far away in the target lane so that the driver can change the lanes. Following which headlight flashing is done in order to communicate with vehicle ahead is shown in Figure 7.

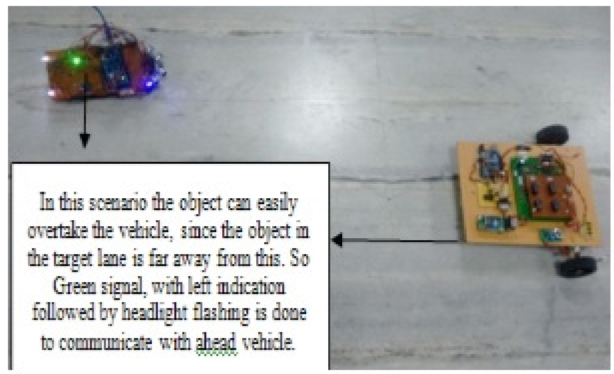

Figure 7. Green alert to driver that object far away.

Scenario 3

Headlights will be turned on automatically when the intensity of Main Light Dependent Resistor (LDR) value gets reduced is shown in Figure 8.

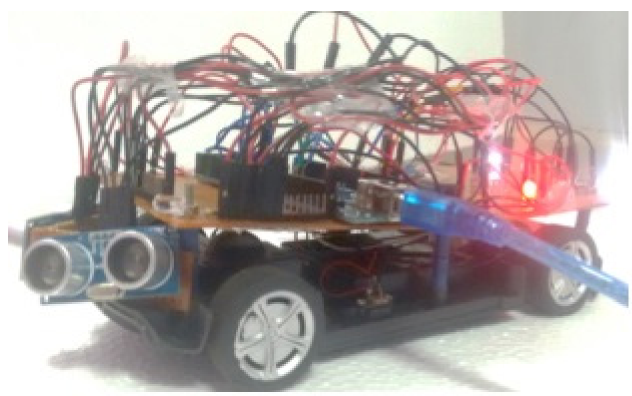

Figure 8. Automatic headlights ON.

Scenario 4

Vehicle approaches in opposite direction to its left, so that Left headlight LED is dimmed until vehicle passes by keeping Right headlight LED is kept in same brighter state is shown in Figure 9. So the detection of object and the accuracy of the model achieve 93% of the target. The

Table 1. Variations between raw sensor data and normalised data

Functions	Raw sensor value		Normalised value	
	X- axis variation (g)	Object detection (m)	X- axis variation (g)	Object detection (m)
Output 1	1.7	2.9	1.1	1.7
Output 2	2.9	3.5	1.6	1.6
Output 3	5.8	3.8	1.8	1.45

proposed model accurately predicts driver's lane changing behavior and glare avoidance to vehicles ahead. Results show that, the prototype attains good expectation performance with better time response characteristics. The system response and GUI based environment is described in Figure 10.

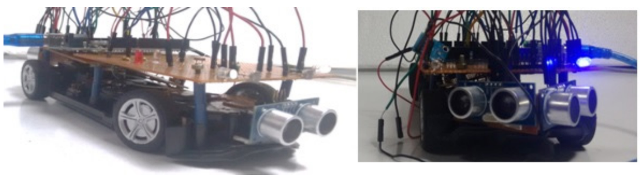

Figure 9. Dimming appropriate headlights.

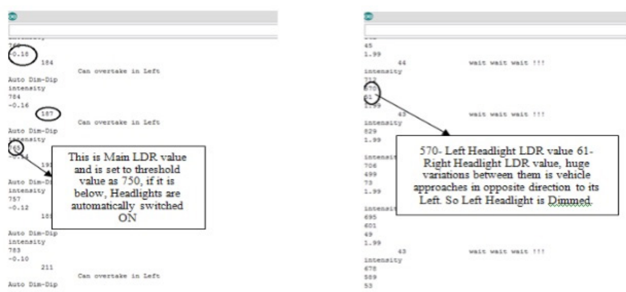

Figure 10. Sensor values in GUI environment.

4. Conclusion

In recent years, the numbers of accidents are increasing; this proposed method presents the solution for the preventing accidents in the form of a tiny prototype. Fusion techniques provides better results in accurate and reliable event detection and decision making that can be included in the upcoming development of this work in real time scenario for the low budget cars. In future it could be designed using Controller Area Network (CAN) with the updated and accurate GPS system to locate the current vehicles position to make the product efficient in terms of low cost with high accuracy alert system[10]. Advanced algorithms to change lanes and ACC can be incorporated as the future features along with self-diagnostic system that can improve the driver safety with its diagnostics and help its own service during repair time. It can be further tried on rough roads to get exact results.

5. Acknowledgement

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