Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 5, May 2021: 2204-2211

Collision Avoidance Systems in Cars

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Abstract

The main objective of this paper was to propose a collision avoidance system that could be implemented in vehicles to prevent accidents. Collision Avoidance System is a system invented to prevent a collision. Whenever a collision is detected, they provide warning to the driver. There are different forms in which these collision avoidance systems are implemented in cars. The various causes for a collision include carelessness of the driver, blind spots on the road to the driver and sudden break down of other vehicles. The proposed approach helped to prevent the collision between the vehicles based on the detection of the obstacles. The system provides information about the possibility of a collision by detecting them. These obstacles are the vehicles that come within the safe limit (the minimum distance that is to be maintained between two vehicles) of the vehicle. This helps the vehicle to take control action on its own. It also provides alert messages. This system is simple and economical. Simulation studies demonstratedthat the proposed system can prevent a collision. It is capable of achieving a realistic collision avoidance system. Experimental results of the proposed system under various conditions are discussed.

Keywords: Accident, Technology, Distance measurement, Collision Avoidance System, Ultrasonic Sensor, Motor Driver, Liquid Crystal Display

1. Introduction

Every year, the number of accidents due to traffic in the world is increasing the same as the number of vehicles. This is caused because of the improper usage of vehicles such as lack of responsibility for the road users to obey traffic signals or a lack of tolerance or mutual respect for the fellow road users. Thus, to prevent this and the hazardous effect it has on others, it is important to communicate all the signals of the impending vehicles on roads and give them alert the drivers if a collision is expected. To achieve this, a collision avoidance system is used. Though this technology is already discovered, there are various problems associated with its installation and working. As a result, it has resulted in few accidents. Collision avoidance systems are still a research topic and lots of care should be taken before installing it for human use.This system aims in preventing accidents either by alerting the drivers or they take the action by themselves. Many proposals for automobile automation are made since the past fifty years but no practical system is developed due to the technological limitations.These systems help in Crash avoidance, ensuring road safety, reducing the driver fatigue, Collision mitigation by braking and preventing injury and accidents. The practical applications of collision avoidance system are used as a warning system for vehicles on roads and in autonomous vehicles.

A. Literature Survey

In order to design a collision avoidance system, literature survey was conducted in this field and the following research papers were found. The research papers and their conclusions are as follows:

"Collision detection and avoidance system for vehicles" has been designed and developed by Saurav Agrawal and Varade, to provide safety to the vehicles, based on the distance of the obstacle in the front direction. This system uses only one ultrasonic sensor in the front direction. It gives an alert signal whenever an obstacle comes closer to the vehicle on the front direction.[1]-[6].

"Obstacle-avoiding robot with IR and PIR sensor" was designed and developed by Aniket D. Adhvaryu et al, proposed that the robots are not only used for a particular application but it can also be used for generalized works. It is applicable for all automation processes used in industries. This system uses IR and PIR sensors in the design process. Results from the research states that the PIR sensors are more sensitive while detecting the human beings than the IR sensor [7]-[11].

"Automatic pre-crash collision avoidance in cars" has been designed by A.Ferrara, developed a control system receives data from the sensors, detects the possible collision, and makes decision on which action is the appropriate decision for the current situation. In case of a collision avoidance manoeuvre, it activates a high level system, which quickly processes the signals and provides the control action [12]-[15].

"The design of ultrasonic distance measurement system based on SOPC' has been designed and developed by Jingjing Du;,Shuiying Zhang;, XueboJin, proposed that this system uses simple distance measurement and alert generation. It uses an ultrasonic sensor to measure distance and a buzzer to produce alert signals. Whenever the distance between the vehicle and the obstacle is below the alarm distance, the buzzer produces an alert signal to the driver. It uses VHDL (Very-High-Speed Integrated Circuit Hardware Description Language) and C software that converts the counter clock pulses to distance and displays it on an LCD. Instead of using a microcontroller, this system used FPGA (Field Programmable Gate Array). This FPGA works on the signals from ultrasonic sensor and provides alert signals.[16]-[20]

"Obstacle avoidance robot using Arduino " has been designed and developed by Pavithra A C; SubramanyaGowthamV, used the concept of distance measurement on all three directions to prevent collision. Initially the ultrasonic sensor measures distance in forward direction. If it is below the safe limit, then the servo motor rotates and the ultrasonic sensor turns towards the left direction and measures the distance. If there is an obstacle in that direction also, the servo motor rotates in the right direction and measures distance. This method uses only one ultrasonic sensor and a servomotor.[21]-[25]

"Research on Safety Lane Change Warning Method Based on Potential Angle Collision Point" has been developed by Tongqiang Ding, Xiaorong Li, Lili Zheng and Zhiguo Hao. They found it essential to determine the actual distance between vehicles, minimum safety distance and warning signal. In order to calculate the position of potential angle collision points between lane change vehicles and obstacle vehicles, it is important to know initial position, initial velocity, acceleration, heading angle and kinematics of the vehicle. This research provides a concept to provide a safe lane change between the vehicles[26]-[29].

2. Methodology

The main aim of a collision avoidance system is to alert the driver in case of an obstacle on its way and take the control action, if the driver fails to respond to the alert signals. In case of autonomous vehicles, the collision avoidance system works as follows.

The LIDAR sensors fit to the front end of the vehicle continuously transmit wave and wait for its reception. If an obstacle comes within the safe distance (300 m), the vehicle automatically stops. It waits till the obstacle moves out of the way or in simple words, the front path is clear.

This leads to serious damages to the vehicle following the other vehicle or may lead to serious accidents. This happens because the vehicle suddenly stops and waits for the obstacle to move from its way.Sudden stoppage of the vehicles may cause damage to the internal parts of the vehicle as well. Hence a simple collision avoidance system is required.

This proposed collision avoidance system involves a simple setup. The microcontroller processes all the signals from input devices and controls the output devices. In order to power and synchronize this microcontroller, battery and crystal oscillator are used. Here the input device is an ultrasonic sensor and the output devices are LCD, motor driver unit and the motors. The ultrasonic sensor continuously measures the distance between two vehicles on the same lane. Whenever a vehicle comes within the safe limit of a vehicle, it is considered as an obstacle by the microcontroller.

Depending on the direction in which the obstacle approaches, the necessary controls are taken by the microcontroller and the signals are sent to the motor driver which controls the direction of rotation of the motor and to the LCD to display the direction to which the vehicle is turning or to provide alert signals.

The block diagram of the collision avoidance system is as shown in figure 1.

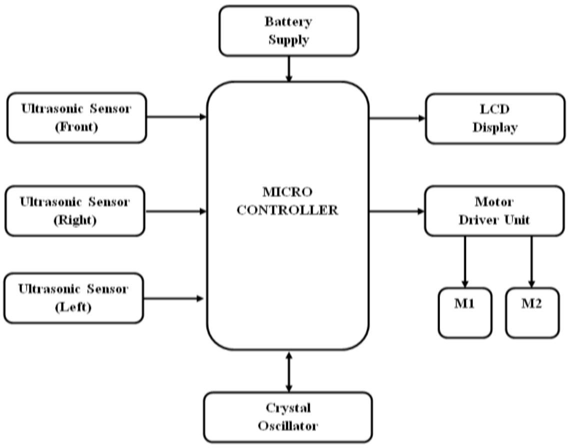

Fig. 1. Block Diagram of collision avoidance system

3. HARDWARE

The microcontroller used here is a 40 pin, 8-bit CMOS microcontroller with 8 KB flash memory and 256 bytes of RAM Atmel microcontrollers. It has 32 I/O pins comprising three 16-bit timers, external interrupts, and full-duplex serial port.

It needs an external battery source to power up the internal connections of the IC and an external crystal oscillator to provide clock signals and to synchronize the performance of the microcontroller. This microcontroller can work on analog signals but requires an external DAC module to work with digital signals.

The crystal oscillator uses a vibrating piezoelectric crystal to create an electrical signal of precise frequency. This frequency is used to track the time to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters/receivers.

Here, obstacle detection is done using ultrasonic sensor. This sensor is used for the purpose of determination of distance. It works in a way similar to that of the bat's communication. This sensor continuously emits frequency signals which when hit by the obstacle, are reflected back. When high voltage electrical pulse is applied to the trigger pin, it generates a burst of sound waves of specific spectrum of frequencies. Whenever an obstacle comes before the ultrasonic sensor, the sound waves are reflected back in the form of echo and generate an electric pulse. The ultrasonic receiver shall detect the transmit waves from the ultrasonic transmitter that is hit on the object. The combination of these two circuits (transmitter and receiver) will allow the vehicle to detect the object in its path.

The time taken by the signal to reach the receiver after leaving the transmitter is used to determine the distance between the vehicle and the obstacle using the following formula.

Distance (in cm) = 0.0344 x {Time (in microseconds)}/2

where 0.0344 represents speed of sound in cm/μs.

The ultrasonic sensor has a multi vibrator at its base. It consists of four pins - GND, VCC, Trigger, and Echo where GND and VCC are the supply pins, Trigger is the transmitter pin and Echo is the receiver pin

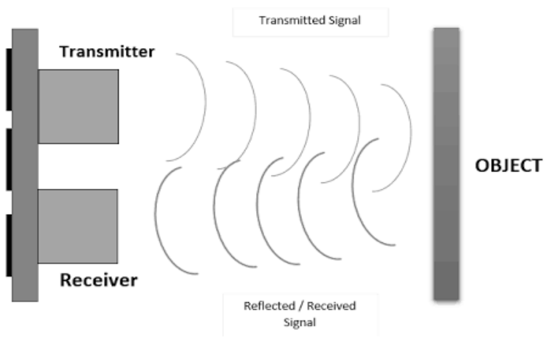

Fig. 2. Working principle of Ultrasonic Sensor

The various features of ultrasonic sensor are High sensitivity, Low power consumption, High reliability, Compact and lightweight and Narrow acceptance angle

This sensor can measure distance in a range of 2 cm to 400 cm. If an obstacle is found close to the front side of the vehicle, it compares the distances on other two sides (left and right). Once this command is distance comparison is done by the microcontroller, it sends signals to the motor driver unit.

Motor drivers are the interface between motors and control circuits. Motor requires a high amount of current whereas a control circuit requires a low amount of current. Hence, the function of the motor driver is to take low current signals from the control circuit and convert it into high current signal for the motor. This controls the direction of turn of the motors.

The motor driver unit is composed of the L293D motor driver ICs which can work on the command given by the microcontroller. It turns to the desired direction by alternately giving high and low values to the pins of the ICs to which the motors are connected.

Table 1 Input for Movement

Direction	Input 1	Input 2	Input 3	Input 4
Forward	1	0	1	0
Backward	0	1	0	1
Left	1	0	0	1
Right	0	1	1	0

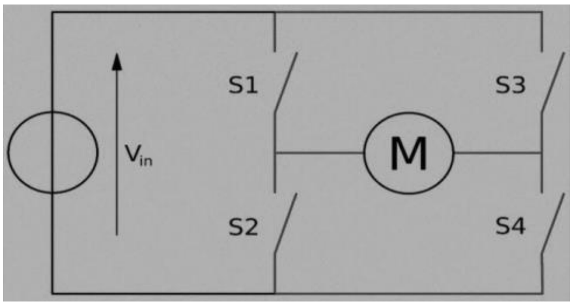

Fig. 3. L293D Motor Driver H Bridge Circuit

The DC motors are connected to the motor driver IC through the microcontroller pins. These pins are used as inputs to the motors. Here, gear DC motors are used. Each motor has a specific speed Each motor takes two inputs; hence four input pins are used. These pins provide power to the actuators. These actuators are responsible for the left, right, forward and backward movement of the vehicle. Therefore, this IC aids for the control of the direction of the vehicle.

A liquid crystal display (LCD) is a thin, flat display device made up of number of pixels arranged in front of a light source or reflector. It is used with battery-powered devices since it uses small amount of electric power. A 16x2 LCD unit acts as a provision for providing the alert signals. It displays the direction to which the vehicle turns.

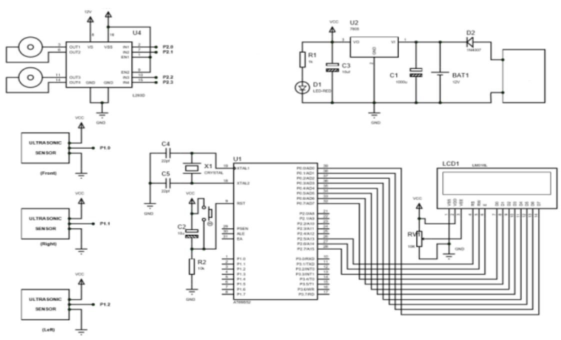

Fig. 4. Circuit diagram of collision avoidance system

Figure 4 shows the circuit diagram of collision avoidance system. The connections are depicted in the following circuit diagram. The connections are made based on the pin configurations of the individual hardware components. The wires are soldered to maintain a stable electric contact. This type of connection is depicted in the key.

4. Flow Chart

Here the obstacles are sensed by setting a safe limit of distance. Whenever a vehicle comes in this safe limit, it is considered an obstacle.The ultrasonic sensors are placed on three sides (left, front and right) of the vehicle. They are meant to continuously check for the obstacle by measuring the distance. If the path corresponding to the front sensor is clear and has no obstacle, the vehicle will proceed in the forward direction.

If an obstacle is found on this path, the sensor readings from left and right sensors are compared. If any of those paths is clear, the vehicle will turn in the particular direction with the help of the motor driver. If the left path is clear, the vehicle turns to the left and goes straight. If the right path is clear, the vehicle turns to the right and goes straight.

If any two paths are blocked, for example, front and left or front and right, then the vehicle moves in the other direction, i.e., right or left.

If all the three sides have obstacles, then the vehicle moves in the reverse direction for a small delay, then takes a left turn and proceeds straight in that direction. It is programmed to take a left turn because the keep left principle is being followed in our roads.

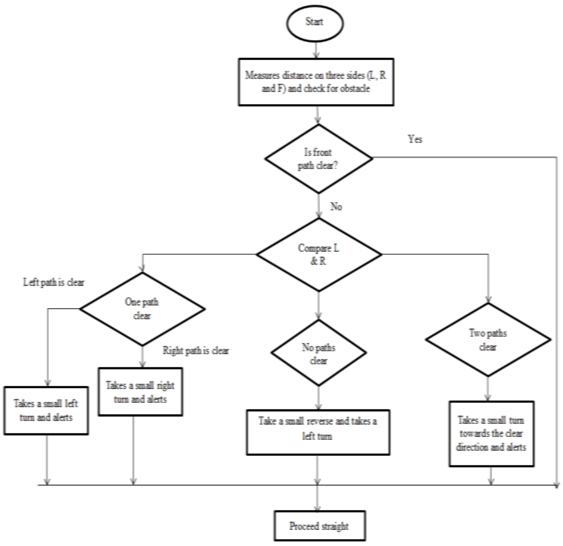

Fig. 5. Flow chart of collision avoidance system

Figure 5 shows the flowchart for the collision avoidance system in cars explaining the actual working of the system. This turning towards the left direction can be programmed and the vehicle can be made to turn in the desirable direction. Every time the vehicle takes a turn or if there is any change in its direction of movement, it is intimated by means of an LCD.

5. Result

The result obtained in the collision avoidance system is that if an obstacle is found on the front side, then the microcontroller checks for an obstacle from the other sensors. It makes a small turn in the direction that is clear and proceeds straight in that direction. Else if there is no obstacle corresponding to the front sensor, it continues to proceed in the same direction. It moves in the backward direction for a small delay and takes left turn and proceeds straight, if no path is found to be clear.

Here, the sensors work continuously and take readings at regular small intervals. This would help prevent a collision. The continuous monitoring of the sensor readings is used as the working algorithm.

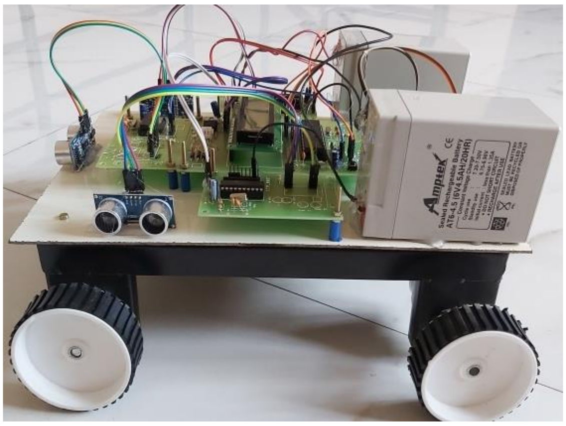

Fig. 6. Prototype of the project

Figure 6 represents the prototype of the collision avoidance system.

Table 2 represents the output response of the system. The tabulated result shows the actual response of the system for every reading of the ultrasonic sensor. It also shows the direction of the obstacle, message that is displayed on the LCD, the direction to which the vehicle turns and the remarks that can be concluded from it.

This table helps to understand the working of the system in a better way. These are some sample readings and their corresponding responses by the system.

Table 2 Output Response of the system

Ultrasonic sensor reading	Obstacle direction	Message displayed on LCD	Direction of turn	Remarks
FF	-	Obstacle Sense ======	-	Moves in straight direction
FE	Front	Obstacle Sense Front	Left	Takes small left turn and moves straight
FD	Right	Obstacle Sense Right	Left	Takes small left turn and moves straight
FB	Left	Obstacle Sense Left	Right	Takes small right turn and moves straight
F8	Obstacles on all three sides	Obstacle Sense =====	Reverse	Takes small reverse and turns left
FC	Front and Right	Obstacle Sense ======	Left	Takes small reverse and turns left
FA	Front and Left	Obstacle Sense ====	Right	Takes small reverse and turns right

6. Conclusion And Future Scope

The project developed is used to avoid obstacles on the road. The vehicle usually travels on the straight path. If an obstacle comes on its path, it turns to right or left and then moves in that direction.

This system can be used in autonomous vehicles because the major problem that is faced in the implementation of autonomous vehicles for human use is that the collision avoidance system of those vehicles requires utmost care and it stops at a very far distance whenever an obstacle is found. This might cause a lot of traffic related problems. Thus, to avoid this and to provide a smooth journey, this method of collision avoidance system can be installed in autonomous vehicles.

This process uses ultrasonic sensors for distance measurement because of its wider field of detection. Though ultrasonic sensors are found to be simple and affordable, it has a drawback. It cannot differentiate between curved surfaces and straight surfaces. In case of a curved surface, the distance measured is the curvature of the surface which is longer than the actual surface.

Thus, to prevent this, image processing technologies using cameras may be installed on vehicles. Though this technology demands higher cost equipment, the performance of the entire system can be improved to a greater extent.

References

[1] S. Xu, S. E. Li, B. Cheng, and K. Li, “Instantaneous Feedback Control for a Fuel-Prioritized Vehicle Cruising System on Highways With a Varying Slope,” vol. 18, no. 5, pp. 1210–1220, 2017.

[2] T. Wada, S. Doi, N. Tsuru, K. Isaji, and H. Kaneko, “Characterization of expert drivers’ last-second braking and its application to a collision avoidance system,” IEEE Trans. Intell. Transp. Syst., vol. 11, no. 2, pp. 413–422, 2010, doi: 10.1109/TITS.2010.2043672.

[3] L. Tu and C. M. Huang, “Forwards: A map-free intersection collision-warning system for all road patterns,” IEEE Trans. Veh. Technol., vol. 59, no. 7, pp. 3233–3248, 2010, doi: 10.1109/TVT.2010.2051344.

[4] W. Song, Y. Yang, M. Fu, Y. Li, and M. Wang, “Lane Detection and Classification for Forward Collision Warning System Based on Stereo Vision,” vol. 18, no. 12, pp. 5151–5163, 2018.

[5] A. Polychronopoulos, M. Tsogas, A. J. Amditis, and L. Andreone, “Sensor fusion for predicting vehicles’ path for collision avoidance systems,” IEEE Trans. Intell. Transp. Syst., vol. 8, no. 3, pp. 549–562, 2007, doi: 10.1109/TITS.2007.903439.

[6] M. Muzammel, M. Z. Yusoff, and F. Meriaudeau, “Event-Related Potential Responses of Motorcyclists Towards Rear End Collision Warning System,” IEEE Access, vol. 6, pp. 31609–31620, 2018, doi: 10.1109/ACCESS.2018.2845899.

[7] J. Mar and H. T. Lin, “The car-following and lane-changing collision prevention system based on the cascaded fuzzy inference system,” IEEE Trans. Veh. Technol., vol. 54, no. 3, pp. 910–924, 2005, doi: 10.1109/TVT.2005.844655.

[8] J. Mar and F. Lin, “An ANFIS Controller for the Car-Following Collision Prevention System,” vol. 50, no. 4, pp. 1106–1113, 2001.

[9] D. F. Llorca et al., “Using a Fuzzy Steering Controller,” vol. 12, no. 2, pp. 390–401, 2011.

[10] D. F. Llorca, M. A. Sotelo, I. Parra, J. E. Naranjo, M. Gavilán, and S. Alvarez, “An experimental study on pitch compensation in pedestrian-protection systems for collision avoidance and mitigation,” IEEE Trans. Intell. Transp. Syst., vol. 10, no. 3, pp. 469–474, 2009, doi: 10.1109/TITS.2009.2018958.

[11] J. Li, Y. Zhang, M. Shi, Q. Liu, and Y. Chen, “Collision Avoidance Strategy Supported by LTE-V-Based Vehicle Automation and Communication Systems for Car Following,” vol. 25, no. 1, pp. 127–139, 2020.

[12] F. Lamiraux, “Smooth Motion Planning for Car-Like Vehicles,” vol. 17, no. 4, pp. 498–502, 2001.

[13] K. D. Kusano and H. C. Gabler, “Safety Benefits of Forward Collision Warning , Brake Assist , and Autonomous Braking Systems in Rear-End Collisions,” vol. 13, no. 4, pp. 1546–1555, 2012.

[14] P. Krishnan, “Design of Collision Detection System for Smart Car Using Li-Fi and Ultrasonic Sensor,” vol. 67, no. 12, pp. 11420–11426, 2018.

[15] S. K. Gehrig, F. J. Stein, and A. P. F. Approaches, “Collision Avoidance for Vehicle-Following Systems,” vol. 8, no. 2, pp. 233–244, 2007.

[16] A. Eidehall, J. Pohl, F. Gustafsson, and J. Ekmark, “Avoidance by Steering,” Transportation (Amst)., vol. 8, no. 1, pp. 84–94, 2007.

[17] D. Chen, Y. Lin, and Y. Peng, “Nighttime Brake-Light Detection by Nakagami Imaging,” vol. 13, no. 4, pp. 1627–1637, 2012.

[18] L. Canzian, U. Demiryurek, and M. Van Der Schaar, “Collision Detection by Networked Sensors,” vol. 2, no. 1, pp. 1–15, 2016.

[19] B. Brito, B. Floor, L. Ferranti, and J. Alonso-mora, “Model Predictive Contouring Control for Collision Avoidance in Unstructured Dynamic Environments,” vol. 4, no. 4, pp. 4459–4466, 2019.

[20] M. Brännström, F. Sandblom, and L. Hammarstrand, “A Probabilistic Framework for Decision-Making in Collision Avoidance Systems,” vol. 14, no. 2, pp. 637–648, 2013.

[21] M. Brännström, E. Coelingh, and J. Sjöberg, “Model-based threat assessment for avoiding arbitrary vehicle collisions,” IEEE Trans. Intell. Transp. Syst., vol. 11, no. 3, pp. 658–669, 2010, doi: 10.1109/TITS.2010.2048314.

[22] M. Bachmann, M. Morold, and K. David, “On the Required Movement Recognition Accuracy in Cooperative VRU Collision Avoidance Systems,” vol. 22, no. 3, pp. 1708–1717, 2021.

[23] J. Alonso-mora, P. Beardsley, and R. Siegwart, “Cooperative Collision Avoidance for Nonholonomic Robots,” vol. 34, no. 2, pp. 404–420, 2018.

[24] Saurav Agrawal; S.W. Varade “Collision detection and avoidance system for vehicle”, 2nd International Conference on Communication and Electronics Systems (ICCES), India, 2017, pp. 476-477.

[25] Aniket D. Adhvaryu et al “Obstacle-avoiding robot with IR and PIR motion Sensors” IOP Conference Series: Materials Science and Engineering, vol. A247, pp. 529-551, April 2005.

[26] A. Ferrara “Automatic pre-crash collision avoidance in cars”, IEEE Intelligent Vehicles Symposium, 2004.

[27] Jingjing Du;,Shuiying Zhang;, XueboJin, “The design of ultrasonic distance measurement system based on SOPC”, International Conference on Intelligent Human-Machine Systems and Cybernetics(IHMSC), 2011.

[28] Pavithra A C, SubramanyaGoutham V, “Obstacle Avoidance Robot using Arduino”, International Journal of Engineering Research and Technology (IJERT), National Conference of Electronics, Signals and Communications (NCESC), vol.6, Issue 13, 2018.

[29] Tongqiang Ding, Xiaorong Li, Lili Zheng, ZhiguoHao, “Research on Safety Lane Change Warning Method Based on Potential Angle Collision Point”, Journal of Advanced Transportation, 2019, vol. 2019, 14 pages.