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Proposed Collision Avoidance System in Driverless Cars

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Abstract- *Avoiding collisions is an important matter in the majority of transport systems and in many other applications in driverless cars it is very important to have an active collision avoidance system since only the car to take an action and no driver to help. The goals of collision avoidance systems are tracking objects of possible collision risks and decide any action to avoid or mitigate a collision with the help of sensors and radars. Car accidents have become quite common nowadays. After investigations, conclusions have stated that a great deal of those accidents happened because drivers fail to stop the car at the right time. Sometimes, the pedestrians are not crossing the road at the right time. Researchers discovered that about 35 percent of people die due to accidents, 98 percent of which die because of fatal road accidents. Many car industries have proposed an AI system in the vehicles for the aim of reducing accidents and this is considered as the backbone of the auto-driven car. However, this system is complex and expansive. That is why; ordinary people are still under the risk of accidents . The system proposed to driverless cars is simulated and modeled via small Miniatures and in Matlab and assembled in Arduino.*

Keywords- *auto-driven car, IoT, avoidance system*

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1. Introduction

Safe and collision-free travel is highly important in modern society. Moreover, it is a significant matter in driverless industrial procedures [1]. In applications of aerospace and navy, radar-based help systems avoid collisions and have been utilized for many years in traditional cars. Presently, collision avoidance (CA) systems started emerging in driverless automotive applications in auto-driven cars. The issue in the design of the CA system is how to balance the efficiency of avoiding collisions in auto-driven versus the risk of false alarms [2]. Driverless automotive applications specifically, raise numerous issues; heavy traffic that causes complicated scenarios with several moving targets (including traffic with or without driver); the dynamical abilities of a car could quickly change, such as, tire-to-road friction could greatly vary from a moment to the other which mean the decision to be taken it is not related to the traffic avoid only since many other factors affect the decision [3].

This paper presents a discussion and proposed system of the general theory for CA decision making and its applications in auto-driven driverless automotive systems. The fundamental focus is to deal with the uncertainties of the process of decision-making and the way of handling complicated scenarios of multiple obstacles. Specifically, there is an introduction of a framework for dealing with uncertainty.[4] The presented approaches utilize various strategies for searching the group of feasible avoidance maneuvers in the driverless environment, in order to find an escape path (if there is any). Some of the new collision avoidance decision functions have been introduced as well. Those functions deal with various problems, like the properties of the suddenly stopped cars and no space high way, determining the best avoidance maneuvers for a model of constant acceleration movement, and changing obstacle dynamics when the obstacle reaches a stop [5].

2. Collision Avoidance

Avoiding collisions is a highly important matter in the majority of transport systems and in a wide range of other applications and it represents the backbone of the driverless cars. The detection and avoidance of a potential collision have been under research for a various application areas, like the air traffic control (ATC), driverless automotive collision avoidance, robot manipulator control, and so on. The goal of any collision avoidance system is mainly avoiding the collision of two or more objects [6]. CA systems prevent collisions either via implementing an autonomous avoidance maneuver or with the use of a warning to an operator and in our case no operator is in the system with the driverless (auto-driven cars). For mitigating collision consequences it is possible to take some other actions, for instance, in a driverless automotive application this could be for the pretension of the seat belts and inflating the air bags; in a fighter aircraft, one could consider ejecting the pilot in the case where a collision cannot be avoided. Any of the actions that are performed by a CA system are referred to as an intervention.[7] Based on application and the considered type of intervention, the measure for asses the collision threat and the decision-making algorithm could greatly vary.[8]

3. Previous studies

Many studies in this area of research try to provide safety alarm to avoid traffic collisions in [12] the authors claimed that Ranging and detection of the front end vehicles are accomplished by combining the RADAR sensors, Hardware's, Communication devices and a Risk zone detection algorithm. By combine, this makes the use of Vehicle collision avoidance system perfect and available to the public allowing safe and secure driving experience. The desired speed and distance can be set at several levels according to the situation. The main goal of this proposed work alerts the driver on vehicle positions and will do on auto diagnostic of the vehicle.

In [13] this scheme contains four major stages: video frame capturing and transmitting, image preprocessing, traffic sign detection, and character/icon extraction and recognition. The smartphone first captures videos and then extracts video frames in certain frame-rate. These extracted frames can be transmitted to an in-vehicle computing device by a wireless network (Bluetooth, WiMAX, Wi-Fi etc.) The preprocess employs some image processing to improve and transform the video frames to keep a stable quality for following detection and recognition schemes. At the following stages, this paper presents some efficient and accurate traffic sign detection and recognition schemes, which contain color selection, shape recognition, character/icon extraction, and recognition.

I. Collision Avoidance Applications

CA systems are utilized in many various fields and under greatly varying circumstances. Typical sensors utilized for the detection of obstacles are radar or vision sensors [9].

II. Driverless automotive Collision Avoidance

Car accidents are one of the main death and injury causes in today's society. Driverless automotive manufacturers started introducing more driver support systems for helping to avoid the occurrence of accidents but in auto-driven cars, these techniques are not applicable since no driver to support. The first step in a CA system for driverless automotive applications is adaptive cruise control (ACC), which is presently available as an option for several vehicle models [4]. ACC systems adapt the speed to any in-path vehicle, should it move slower than the predefined host vehicle speed. A considerable issue in driverless automotive collision avoidance lies in the fact that even in normal driving; the situation of traffic could be highly complicated from a sensing viewpoint, with several obstacles that need to be found and categorized. One more problem is that typically, the tire-to-road friction is not known and could change rapidly the car must take an immediate action to avoid crash [10].

III. Applications of Aerospace

Radar-based air traffic control (ATC) systems are now used for many years. Traffic alert and collision avoidance system (TCAS) are utilized onboard US transportation aircraft since the early 90s. Those systems usually have the goal to help pilots and air traffic controllers to keep a regulated minimal separation between any two aircraft. A breach of this distance is known as a conflict, [10]. In [11] an extensive survey of approaches for avoiding collisions in ATC systems is illustrated. This field is drawing ever more attention as the airspace that surrounds big airports turns more crowded, [11].

4. Proposed System

Our system is implemented in two-phase, the first phase use real materials and small cars that is controlled via arduous and second one is simulation via Matlab. Firstly, when the car engine goes on, it searches for obstacles. In the case where there's an obstacle only in front of it then it doesn't give an order to move and it will start avoiding same with backward movement. In the case where the road is empty, it starts moving forward while continuously checking if there are any obstacles. When there's an obstacle it detects it and estimates separates them. Simultaneously the sensor on the other side performs the same process and sensors at the car sides. This way, ultimately the car looks for obstacles and if it finds any, it slows down. If the distance is below the accepted limits, the car sends an alert via several methods of avoiding. Now, in the case where there are obstacles from all the sides then the auto-driven car performs a comparison of which one of the sides is closest to the obstacle and after calculating, it responds with the suitable speed variation at the forward or backward direction.

In Figure 1, the car will totally count on the sensor that is in front and back of car and side sensors to locate the conflicting traffic and try to provide the proper solution to this possible conflict.

The system situation will mainly go from the point where no avoidance needed to the point where avoidance will be not useful (the crash point), this situation is represented in Figure 2.

1. Normal operation: In this situation, there isn't any imminent collision risk.

2. Collision avoidable: in this case, there is a risk to the car. A non-negligible threat exists that a collision may happen. Here, it is still possible avoiding the imminent collision with a suitable avoidance maneuver. Usually, humans as dangerous perceive this case. What is seen by a CA system as a dangerous case will definitely differ based on the decision function that the CA uses. It is typical in this case that collision-warning systems will be activated. Any system that is designed for avoiding collisions must operate in this case.

3. Collision unavoidable: here, a collision is imminent, and there is no chance to avoid it using any maneuver. Even though the collision is unavoidable, it could still be possible to slightly reduce its severity with the reduction of the collision speed and by performing other mitigating actions.

4. Collision: in this state, a collision happens.

5. Post-collision: this is the state in which a collision has happened. In the case where the CA system is still operational, actions for avoiding secondary collisions may be taken.

Each sensor and radar will provide a distance for our current car to all surrounded traffic as shown in Figure 3 if the distance stay in the acceptable levels and remain constant the no need for decision to make, only if sudden conflict happen or the front or rear car comes closer to the traffic then the decision is been made to move right or left of the traffic and brakes will be used to reduce speed of the car and to give the avoidance system more time for movement and to void sudden crash as possible.

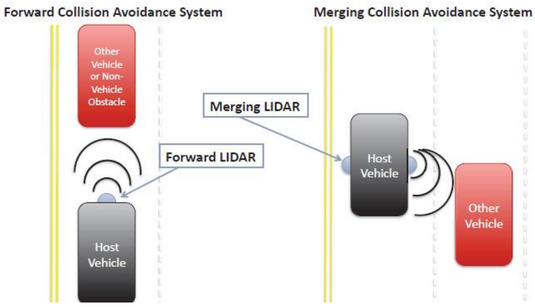

Figure 1: Avoidance system main sensors

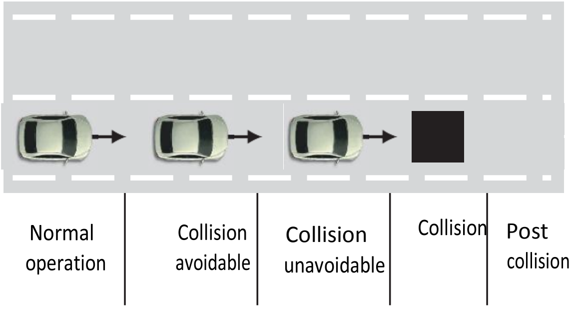

Figure 2: Avoidance situations

Figure 3: Surrounded traffic speed, position, and distance

Using the Hall Effect sensor for velocity and the LIDAR-Lite sensor to read the distance, the formula to calculate the avoidance/stopping distance shown below

Acting (avoid, stop) =2.3*V^2/2mg

Where g is gravity, V is the current velocity, and m is the coefficient of friction. All of our sensors and values for this equation are in centimeters .

If the distance is change rapidly than an estimated time to meet (the traffic) with this traffic will be calculated to help the system to avoid the possible conflict, Figure 4 shows how the proposed system can provide some information on the upcoming conflicts with the estimated information on the other traffic speed curve and all the useful information to do calculation to avoid.

Figure 4: Conflict time shows override

In Figure 4 the left picture shows two numbers of speed the first one is the current speed which is 76 and the other one is the required speed to avoid a crash which is 73, the incident obviously happens on a freeway, with the auto-driven vehicle that occupies the left-most lane. Because the set speed value is 73 mph, but the car is currently driving at 76 mph, clearly, the throttle override has not only induced a headway lying in the conflict window but has caused the speed to be more than the set speed as well. A review of the forward video from this driver's continuing correlation with the indicated target car proves that the host driver seems to act quite aggressively, in an attempt to pass.

It is presumed, then, that the throttle override tactic has been associated with that intent.

In Figure 5 the left picture shows two numbers of speed the first one is the current speed which is 75 and the other one is the required speed to avoid a crash which is 80,the incident clearly will not occurs at all, with the auto-driver car that occupies the left-most lane. Due to the fact that the set speed limit is 75 mph, however, the vehicle is currently driving at a speed of 80 mph, clearly, the throttle override won't induce a headway which lies.

In Figure 3 the proposed system shows how to deal with the possible traffic (more than one) and avoid accrue to the main factors (speed, direction, and distance) which are mainly taken from sensors and radars.

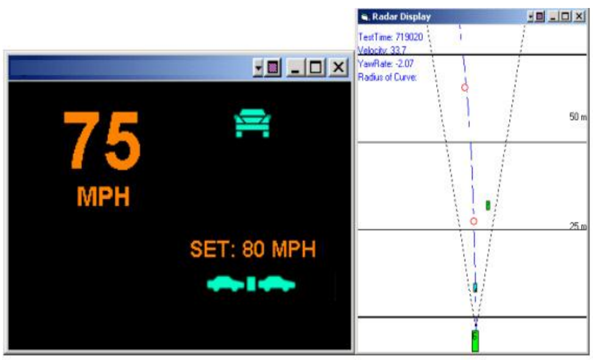

Figure 5: Conflict time shows (not effectors)

IV. Main conflicts situation

The situation where the conflicts will affect the safety of the car and the passengers, the avoidance system should work with more than one situation

- The first scenario, as illustrated in Fig. 6, tests the capability of the system of recognizing the dynamical state of a slower lead car (constant speed) and sends an alert and action in accordance to that.
- Figure 7 depicts the second test case in which the SV is initially following the POV at a constant time gap and after that, the POV suddenly slows down.
- Figure 8 illustrates the 3rd case, testing the capability of the FCW function in detecting a stopped lead car.

- The 4th test case is involved with the SV that makes a signaled lane change and after that, coming across a slower POV at a constant speed as depicted in Figure 9.

IIV. System flowchart

The distance in the flow chart is basic and it needs to be reviewed after checking the system in real environment as well as the number of sensors used.

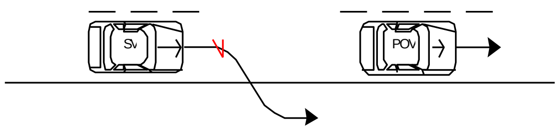

Figure 6: Slower Lead Car

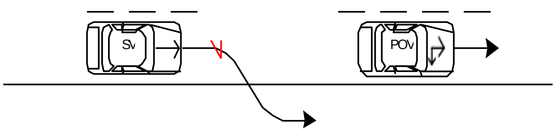

Figure 7: Decelerating Lead Car

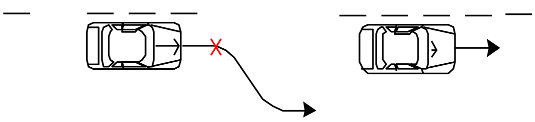

Figure 8: Stopped Lead Vehicle

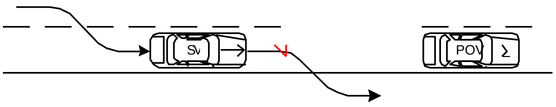

Figure 9: Slower Lead Car after Lane Changing

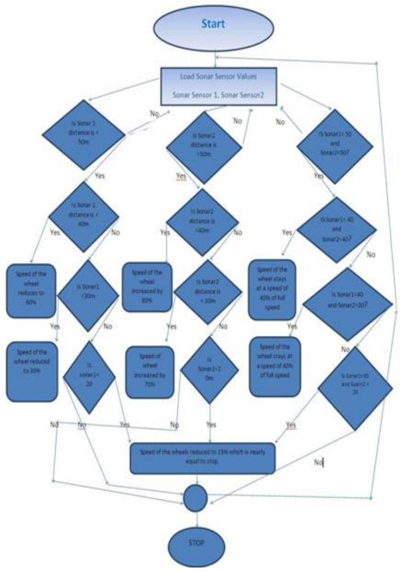

Figure 10: System flow chart

5. Sensors used

Many sensors were used with the sampled automotive car

Cameras

One of the biggest upsides behind it is the optical aspect, which enables an autonomous vehicle to literally visualize its surroundings. Cameras are very efficient at the classification of texture interpretation, are widely available, and more affordable than radar.

Radar is an abbreviation for radio detection and ranging. In a computational context, radar is lighter than a camera and uses radio waves to determine the distances of objects, exact speeds they're going, and even angles they're facing.

Wireless sensing sensors for distance and speed approximation.

6. Conclusions

Traffic collision avoidance system in driverless environment need to set a decision making algorithm which will lead to cover most of situation where the car need to take an action to avoid crash, the decision is basically taken according to set of factors plus the situation itself, the speed of the forward traffic and distance between the car and other traffic should collected continuously.

Many of sensors (speed and distance) plus radar and camera should provide to provide wider area of the decision to take.

References

[1] H.L. Bloecher, J. Dickmann, and M. Andres, "Automotive active safety & comfort functions using radar," Ultra-Wideband, ICUWB 2009. IEEE International Conference on. IEEE, 2009.

[2] J.J. Breuer, E. al. "Real world safety benefits of brake assistance systems," 20th International Technical Conference on the Enhanced Safety of Vehicles (ESV). No. 07-0103. 2007.

[3] H.G. Dagan, L. Erez et al. "Forward collision warning with a single camera," Intelligent Vehicles Symposium, IEEE. IEEE, 2004.

[4] Y.T. Distner, S.T. Martin et al. "City safety—a system addressing rear-end collisions at low speeds," Proc. 21st International Technical Conference on the Enhanced Safety of Vehicles. No. 09-0371. 2009.

[5] A. Hanna, B. William, and G.R. Widmann, "A strategy to partition crash data to define active-safety sensors and product solutions," No. 2008-21-0032. SAE Technical Paper, 2008.

[6] S.R. Nakaoka, M.R Masumi, P.P. Raksincharoensak, and Masao Nagai. "Study on forward collision warning system adapted to driver characteristics and road environment," Control, Automation and Systems, 2008. ICCAS 2008. International Conference on. IEEE, 2008.

[7] S.S. Park "Research on a Vision Based Active Forward Collision Avoidance System," Master's Thesis, Graduate School of Automotive Engineering, Kookmin University, 2010.

[8] R.H.A. Stein, P. Gideon, Y. Gdalyahu, and A. Shashua, "Stereo-assist: Top-down stereo for driver assistance systems." Intelligent Vehicles Symposium (IV), IEEE. IEEE, 2010.

[9] D.G. Sun, Zehang, G.E. Bebis, and R.R. Miller, "On-road vehicle detection: A review," IEEE transactions on pattern analysis and machine intelligence 28.5: 694-711, 2006.

[10] N.R. Verma, K.M. Mukul and A.G. Goertz. Preliminary Evaluation of Pre-Crash Safety System Effectiveness. No. 2010-01-1042. SAE Technical Paper, 2010.

[11] J.E. Kuchar and A.C. Drumm, "The traffic alert and collision avoidance system," Lincoln Laboratory Journal 16.2: 277, 2007.

[12] R. Sivakumar and H. Mangalam. "RADAR based vehicle collision avoidance system used in four wheeler automobile segments," International Journal of Scientific & Engineering Research 5.1 2014.

[13] Ching-Hao Lai, Chia-Chen Yu, "An Efficient Real-Time Traffic Sign Recognition System for Intelligent Vehicles with Smart Phones," International Conference on Technologies and Applications of Artificial Intelligence,pp.195-202, 2010.