INTELLIGENT TAILGATING WARNING SYSTEM

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ABSTRACT

With an increasing number of road accidents, the everyday safety of vehicles on the road has become paramount nowadays. However, there are many factors for accidents but distracted and reckless driving top the list. Cutting off other cars and tailgating are two prominent examples of reckless driving, which may cause severe accidents leading to loss of life and wealth. This can be avoided if the driver is altered about the risk of his actions from time to time. This paper will mainly focus on alerting the driver about tailgating and avoiding unexpected collisions with the front car. The two seconds rule is considered the golden rule when it comes to tailgating. Few solutions address this problem using the radar signal and inbuilt Electronic Control Unit (ECU), making them vehicle-specific. Extending these ideas, we provide a solution that connects the radar signal to the driver's mobile application directly and does the computation to enforce the 2-second rule. Over time, with the collected dataset, we can also predict the condition for tailgating and alert the driver beforehand on tailgating prone situations, which could be based on a particular driving zone, traffic condition, or driver's driving history. This will eventually result in alert driving, reducing the hazard caused by tailgating.

Index Terms-Road-Safety, Radar Sensor, ECU, 2-second rule, CAN, Logistic Regression

INTRODUCTION

With increased traffic, thousands of road accidents happen daily in this fast-moving world. These accidents come with a cost of life and wealth. The fact released in 2016 by National Highway Traffic Safety Administration (NHTSA) shows that, on average, 102 road accident-related deaths happen every day only in the USA. There are many reasons why road accidents happen; recklessness and distracted driving such as cutting off other cars and tailgating are at the top of the list. In specific, tailgating is an act of driving too close behind a vehicle, leaving no space to avoid rear-end crashes on any emergency stop. According to data released by the National Center For Statistics And Analysis (NCSA, 2010), rear-end collisions accounted for more than 1.8 million (30.4%) of the 5.9 million police-reported automobile accidents in the United States between 2006 and 2008, resulting in more than 2,200 fatalities and nearly half a million injuries each year[8].Tailgating can be avoided by careful driving and following the "2-second rule," which states that the driver at the back should maintain a safe distance of 2-second between the front vehicle, which will provide enough time to stop without collision on an emergency stop. Further, a survey conducted in 2010 on Rhode Island highways shows that "more than 60% of drivers were tailgating during rush hours and 40% during non-rush hours"[8].

The autonomous driver assistant system is an emerging field of excellence, and few pieces of research address the problem mentioned above. Primarily the existing solutions use the radar system integrated with the vehicle's inbuilt Electronic Control Unit (ECU) to capture and calculate the relative distance between the front car and alert the driver if it is moving too close to avoid rear-end collision. Even if the proposed solutions are efficient, radar integrated with ECU makes it vehicle dependent. A driver not driving a car embedded with such an inbuilt feature can not access this service for safe driving. Extending these ideas, in this paper, we are proposing a solution to this problem using mobile computing. We are offering a solution that will integrate the radar signal generated by the Radar sensor with the user's mobile phone to calculate the proximity from the front vehicle and alert the driver if they violate the 2-second rule. Further, with advancements in mobile phones like Google Pixel 4, which has its radar system, in the future, we can remove the use of external radar sensors as well. With the collected dataset, over a few years, we can also make predictions on tailgating prone situations, which could be based on a particular driving zone, traffic condition, or driver's driving history, and alert the driver beforehand.

RELATED WORK

Recently, the enhanced driver assistance systems in modern automobiles have increased exponentially. These systems primarily focus on integrating the vehicular sensors with the automobile's ECU to perform the computation and assist the driver in safe driving. The current solutions to avoid rear-end collision due to tailgating are very system dependent and come as a feature to the vehicle. They use the radar sensors, ECU, and Controller Area Network (CAN) to determine the distance between the front car and their relative speed. Such an approach has been published as "CAN Coach: Vehicular Control through Human Cyber-Physical Systems." This solution to enforce the 2-second rule has reduced the average time-gap error by 73 percent and improved consistency[7]. This also proves that making this system easily accessible without any vehicle feature dependency will improve safe driving considerably.

DRAWBACKS

The primary drawback of this approach is that it comes as a feature to the vehicle and is hardware-dependent. A user with a vehicle not having such a system can never enjoy this safety feature which might turn out as a lifesaver. Further, the data generated by this approach is local and not stored for further analysis. We can use the day-to-day generated data to enhance the safety feature in the future.

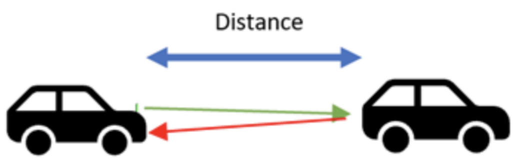
OUR IDEA

This paper talks about a solution for drawbacks in the current solution. We introduce a more efficient way of combining radar sensors and smartphones to prevent accidents even in high traffic areas. Our idea in this paper is that the waves emitted from the radar sensors can be captured by the smartphone and using an algorithm to calculate the 2-second threshold distance between any car and notify the driver via smartphone and smartwatch if the distance is lesser than the threshold distance. This way the driver can avoid accidents or at least prevent the intensity of the accidents.

DETAILED SOLUTION

Let's consider the first scenario where the car comes with a pre-installed RADAR sensor which is integrated with the ECU. This will be a simple case, where the idea is to build an app that can calculate the distance based on the wavelength/frequency of the signal transmitted by the RADAR and the time it took to travel back after detecting an obstacle or car. If the time to cover that distance is less than the threshold the phone and smartwatch vibrate (by the data already collected by the sensor) alerting the driver to take the necessary action to avoid the accident.

Not every car will have a RADAR sensor installed. Then our actual use case arises where we can install any RADAR sensor and use an application on a smartphone to decode the signals from these sensors to calculate the distance between the cars to alert the driver of any probable accidents or collisions using the '2-second' rule explained in earlier sections. The application uses GPS to calculate the recipient car's speed and calculate the speed and direction of the target cars nearby utilizing the radar sensor installed. The application is not designed to transform the smartphone into a virtual, stand-alone radar detector; instead, they are designed to interact with a real radar sensor. The applications merely supplement the functions (augment the features of the specific RADAR) of the radar detectors with which they are meant to work using built-in antennas. Radio Detection and Ranging emit electromagnetic waves, which reflect the waves upon contacting any obstacle. A long range RADAR sensor using the 77 GHz band is installed near the car's bonnet, which emits the waves and is returned to the sensor on contacting an obstacle. The Long range radar sensors provide ranges of 80 m to 200 m or greater and better accuracy which is very crucial for our application. The diagram below shows how electromagnetic waves can calculate the distance and time between two cars.



The following formula calculates the distance between the two cars: Distance = c * T/2, where c = Speed of light 3*108 and T = Time it takes for the signal to come back. Using the RADAR, we can also calculate the speed and direction of the car by the doppler effect. The speed of the target car(V) can be calculated using the formula - Fd *μ/2 where Fd represents the shift in frequency and μ means the wavelength emitted from the radar sensor. Based on the obstacles and type and shape of the surface of the automotive, the car's direction can be found. If the speed of the target car is beyond the set threshold and the car's direction collides with the recipient car direction, the application is designed to output an alarming sound or vibrate to get the user's attention. The current application can only detect the RADAR waves based on pre-collected data but not interpret them or detect the live traffic actions to provide any results. Our application detects the radar waves and analyzes them to help in preventing accidents accordingly.

FUTURE SCOPE

With the advancements in technology, cell phones can be used as a vehicle's own radar device in the future. Using this, the driver can be alerted if a vehicle is too close to it. Cell phones can be mounted in front of the vehicle and they can be used as radar devices to detect the motion of all surrounding vehicles to avoid accidents and ensure safety while driving. Even though cell phones work on frequency bandwidths and cannot pick up radar signals, some new technological innovations show the potential of usage of cell phones as radar detectors for safe driving.

For example, the Google Pixel 4 model of 2019 does motion detection by acting as a radar device. The radar sensor of Google Pixel 4 lets you control your phone without touching it. It works on a frequency of 60GHZ and can detect the motion/gestures of surrounding objects [1]. Pixel 4 radar sensor can detect only slight movements to a specific distance. Google Pixel 4 sensor soli does not travel very far and detects distances up to 30 cm or 1 feet.

In the coming years, Google Pixel 4's sensor soli can be improvised to detect more considerable distances and to operate at frequencies that make motion detection more accurate and easy.

STATISTICAL ANALYSIS

With the proposed method, we can generate data relevant to tailgating. When the 2-second rule is violated, we can store data such as the vehicle's location, speed, time, traffic condition, and driver's information. With enough data, we can address a problem where we can predict the tailgating condition based on existing data and alert the driver in advance. This problem statement can come under the binary classification, and we can use a simple logistic regression model to predict the tailgating condition. This kind of alert system can be beneficial during rush driving, which has been proven to cause 60% of rear-end collisions. Building such a regression model is not that complicated, but we need an ample amount of data that might take a few years to generate from the system to make accurate predictions.

CONCLUSION

With the proposition of our idea to use Radar sensors integrated with mobile phones and eventually utilize the smartphones itself as long range radar sensors in the coming 4-5 years, our algorithm to calculate the possibility of a crash based on '2 second rule' will prevent accidents on the road radically. Further, we propose a prediction model that can predict the tailgating condition based on previous data, which will be generated over time. With this application not just the automotive vehicles but even bicycle and bike riders, pedestrians can be protected on the road.

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