Suggestions on Over-the-horizon Cloud Warning System for Collision Avoidance of Two Intersections

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Abstract. As the highway transportation network expands and modern technologies in the automobile industry develops, automobiles contribute a lot to human life, which have also led to many problems such as traffic accidents, traffic jams, environmental pollution, and energy waste. Take traffic accidents as an example. According to the China’s website of the State Administration of Work Safety, in 2011, about 211,000 people died or injured in traffic accidents, with the death toll hitting 62,000. Among all those accidents, rear-end collisions account for a large proportion, as the freeway rear-end accidents was about 33.4% of the total accidents in China and 24% in America. These traffic accidents have not only resulted in huge economic losses, but have also made highways more congested and occupied medical resources.

1. Introduction:
The forward collision warning system (FCWS) is an active safety system which adopts millimeter-wave radar sensors to monitor vehicles ahead in real time, and, based on the operating status of the vehicles, locates the target vehicles through the Kalman filter algorithm. Plus, with the help of the two-level early warning strategy algorithm, when the vehicle is at the risk of a forward collision, the system will issue warning signals to drivers such as voice prompt, vibration of steering wheel and cushion. According to the tests on road with real vehicles, the system can avoid vehicle forward collisions.

2. Collision Accident Detection Scheme
To avoid collisions through early warnings as mentioned above, on-board equipment must be configured for vehicles as follows. To enable vehicle nodes to obtain real-time positions of vehicles, a global positioning system is required; to allow vehicles to send and receive data messages, a data communication module is a must; to determine whether or not the accident has happened, a data processing module is needed. Thanks to the above equipment and modules, the vehicle nodes can autonomously detect accidents and send messages based on a predetermined method.

Detecting potential accidents can help drivers change their operations in advance to avoid accidents. As shown in the figure, suppose that vehicle A and vehicle B in the accident detection area are at (xa, ya) and (xb, yb) respectively, their driving speed vectors are (μa,νa) and (μb,νb), and the intersection is (x0,y0). Obviously, if a collision happens, both cars must be at the intersection at the same time.

3. Oversight anti-collision warning
Over-the-horizon warning system for collision avoidance of two intersections can gather information about driving, such as roads, surrounding vehicles, pedestrians, and traffic signals, through sensors of environmental perception. The information is analyzed and helps to make decisions, and then vehicles are automatically guided by the chassis control system, which improves the safety of the vehicles.
addition, the collision warning system is important to the research of the intelligent transportation system, thus receiving wide attention. In the system, modern information technology and sensing technology are used to improve drivers’ perception ability. Thanks to sensing technology, information about the surroundings (such as vehicle speed, distance to obstacles, etc.) is transmitted to drivers, and based on the vehicle and road conditions they will identify whether there is a potential hazard. Once a dangerous situation is detected, an alarm will be sent to the drivers so they have time to take actions, which acts as an important means to reduce traffic accidents due to human errors, and makes vehicles safe and reliable. Therefore, a real-time, reliable, and adaptable collision warning system plays an important role in improving safety of vehicles. The system detects vehicles and gathers information of vehicles in the front and rear as well as obstacles, such as the speed and acceleration of the host vehicle and the relevant vehicles, the distance between two vehicles, and other parameters. Then a safety distance model is used to judge the rear-end collision, and relevant actions are taken, including sending an alarm or triggering braking.

4. **Domestic and Foreign Comparison**

Foreign researches on over-the-horizon warning system for collision avoidance began in the late 1980s and were mainly carried out in Germany, the United States and Japan. However, as the researches on this subject in China lag behind, there is a gap with developed countries. In 1994, employees of Daimler-Benz Company proposed a forward collision warning system based on the front radar to detect obstacles in front of the vehicles. After analyzing the information, they believed that the forward collisions were subject to the driver’s response time. The system used radar to scan the area in front of the vehicle in real time, and processed the information, which is scanned by the relevant software in real time, about obstacles in front of the car, while the parameters of the car, such as speed, steering wheel angle, accelerator pedal and brake pedal, were obtained by the sensors installed on the car. This information helps to calculate the relative distance and safety distance between the host and the lead vehicle. Therefore, the driver will receive a warning when it is considered dangerous.

In 2005, General Motors Company of the United States first demonstrated a V2V (Vehicle-to-Vehicle) system for information exchange technology. It is based on the global positioning system and is equipped with wireless communication devices which can alert the driver whether there is a vehicle in the blind spot or whether there is one when the drive enters a curve. In addition, it can also make statistics such as speed, direction and vehicle acceleration to predict whether there is a risk of collision. These warning signals can be sent out in the form of images, sounds, or through Magic Fingers vibrating cushions. If these prompts fail to alert the driver to take actions, the system can also automatically connect the brake device for emergency braking. As computer technologies have developed rapidly in recent years, the performance of the message transceiver for the vehicle-to-vehicle information exchange technology has been improved, and the volume has also been reduced.

In September 2009, General Motors demonstrated a new generation of vehicle-to-vehicle system in Shanghai. With the help of wireless communication, GPS technology as well as the V2V message transceiver installed in the car, each car produced by General Motors can quickly locate its own position and monitor other vehicles and facilities on the road in real time. Meanwhile, the system transmits the monitored information to the driver through the screen and voice, so that he or she can detect potential driving hazards in time.

Unlike General Motors, Toyota Motor Corporation uses millimeter-wave radar and CCD cameras to dynamically monitor the distance between the host vehicle and the lead vehicle. When the distance between the two vehicles is less than the specified value, the system will issue a visual alert to the driver. Nissan embraces “Automatic Emergency Braking” which uses the advanced distance monitoring system to dynamically monitor the following distance. When it is necessary to slow down or brake, the braking light turns on to alert the driver and how the driver releases the accelerator pedal is timely monitored. Companies such as Daihatsu and Mitsubishi also use lidar as a following distance sensor and adopt windshield displays to warn drivers. In 2007, the Ministry of Internal Affairs and Communications of Japan decided to reserve a 700MHz frequency band for the vehicle communication system which can
prevent collisions between vehicles through wireless network communication.

In Israel, Dagan et al use a simple CCD camera to detect obstacles in front of the vehicle and establish a front collision warning algorithm for vehicles \cite{2}. Through the one-dimensional scanning of the CCD camera, the position and distance of obstacles in front of the car are detected. The one-dimensional scanning, compared with three-dimensional scanning, reduces the scanning point and cuts the cost while maintaining fast speed and high stability. The algorithm calculates the time when the car will collide in the future and compares it with the safety time threshold to determine the safety of the vehicle.

Countries like Europe, Germany, France, Italy are also engaged in the research and development of vehicle collision avoidance technology. The European Open Fund diverts its attention to driver monitoring, road environment perception, visual enhancement, front-vehicle distance control, and sensor fusion, while supporting researches on longitudinal and lateral collision avoidance. Germany-based Volkswagen develops a “a warning system for obstacles in specified lanes” which can predict whether a vehicle driving in the opposite direction poses a threat to the driver intended to overtake. In addition, six companies including Audi of Germany, BMW of Germany, DaimlerChrysler, Fiat of Italy, Renault of France, and Volkswagen of Germany established an inter-vehicle communication alliance in early 2005, which aimed to develop inter-vehicle communication based on wireless LAN technology, and to establish European common standards for communication between vehicles and basic equipment.

Domestic researches on vehicle collision avoidance on highways are lagged, but great progress has been made. The accuracy of the collision avoidance warning system has been improved after a variety of researches are made. For example, the braking process of vehicles has been analyzed; the practical safety distance model for the highway has been established; the main factors for avoiding rear-end collisions have been discussed; the braking distance is measured after the driver’s driving style and road conditions are considered.

5. Comparison of anti-collision techniques

The key to the technologies of vehicle collision avoidance warning lies in the means to improve vehicle safety and reduce traffic accidents. At present, although the dominant technologies are based on radar, thermal imaging and ultrasonic technology, they are expensive, less popular, and are obvious to determine. The vision-based technology for vehicular collision avoidance has become a hot spot of current researches because of its popularity and low cost. Thus, the following popular researches are analyzed and compared.

1. Detection and analysis of cloud environment: The driving environment monitoring system consists of an environment detection system and a detection system for vehicle conditions. The former system is composed of millimeter-wave radar, lidar, CCD camera and road sensors that can determine conditions of the road surface to measure the inter-vehicular distance and the location of the lead vehicle. The sensing technology of the vehicle surrounding is the key to preventing car collisions. As the performance of sensors will affect the performance of the entire system, only when the sensors are more reliable, it is possible to reduce the false alarm probability of the system. The millimeter wave radar is installed at the center of the front end of the vehicle, while the lidar on both sides of the millimeter wave radar, which can both measure the distance and the position between the host and the lead vehicle, and can transmit the measured data to the system for judgment. CCD camera obtains images of the lead vehicle and obstacles; the road sensor obtains the information of the roads; the detection system for vehicle conditions measures the speed, acceleration of the host vehicle; all information will be sent to the cloud for judgment.

2. Cloud-based judgment of collision avoidance: After the information is processed of millimeter wave radar, lidar, CCD camera and other sensors, the distance and relative speed of the nearest vehicle or obstacle ahead are estimated and sent to the cloud danger alarming system. The system calculates the “critical inter-vehicle distance” based on the road conditions (wet/dry), the conditions of the host vehicle (such as vehicle speed, steering angle, and lateral swing rate), the distance and relative speed from the lead vehicle, and the driver’s response. Then as the critical inter-vehicle distance is compared with the measured distance, at a certain moment when both two distance is close, the alarm issues a warning
signal. However, when the actual measured distance is equal to or less than the critical inter-vehicle distance, the braking device is automatically activated. When the judgment system for collision avoidance is working, it calculates the safe distance through data processing based on the measured distance between the two vehicles, speed of the host vehicle, relative speed and other information, and compares it with the actual distance measured by the radar. If the measured distance is less than the safe distance, an alarm will be issued. If the driver has not taken measures and the safe distance is less than the limit safe distance, the system will control the car’s conventional braking system through the actuator to slow the car. When the safe distance is over the limit distance, the braking mechanism returns to normal.

6. Summary
As the machine vision technology develops, its ability to accurately detect the road traffic and low cost have reflected the promising applications of over-the-horizon warning system for collision avoidance. The system is composed of three parts: The first part is the detection and tracking of the lane lines, which can distinguish the car in this lane from the one in other lanes, and can prevent false alarms especially when the car is in a curve; The second one is to detect and track vehicles, while the third is to measure and calculate vehicle safety distance.

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