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Collision Avoidance System: A Bright Future for Automobile Industry

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Abstract
Since the invention of mechanized and high-tech vehicles, road safety has been a major subject of concern and had called for an attention with increasing road accidents across the world. As a result, various collision avoidance systems have developed each ensuring better safety than the existing systems. The collision avoidance system, the technology a majority of cars have started adopting for the safety of their customers. It is ideal to be called a life saver as it reduces the severity of an accident, which otherwise would cost lives and property damages. Today, this system generally has camera sensors and radars or laser to detect and warn the drivers of any danger lie ahead on the road, it could be a car, a pedestrian, a stationary object such as a pole or tree etc. Today, there are several advanced features the system accompanies, such as audio warning the driver, pre-charging of brakes, automatic partial or full braking etc. to avoid any fatalities and pre-crash system is one of the best system used nowadays.

Keywords
Road Accidents, Safety, Pre-crash System

I. Introduction

According to the "Global Status Report on Road Safety 2013" by World Health Organization (WHO), more than 1.24 million people die every year due to road traffic injuries, and is the eighth leading cause of death globally. If this continues, it is accepted to be the fifth leading cause of death globally by 2030, forcing the law makers to applyprecautionary measures to reduce the number of deaths on road.
WHO-suggested five pillars that guide national road safety plans and activities;

Pillar 1: Road safety management
Pillar 2: Safer roads and mobility
Pillar 3: Safer vehicles
Pillar 4: Safer road users
Pillar 5: Post-crash response

Various factors contribute to the risk of collision, such as vehicle design, speed of operation, road design and environment, driver skill and behavior etc. The WHO report on road safety has stated that of all the road user types, the maximum fatalities are among car occupants.

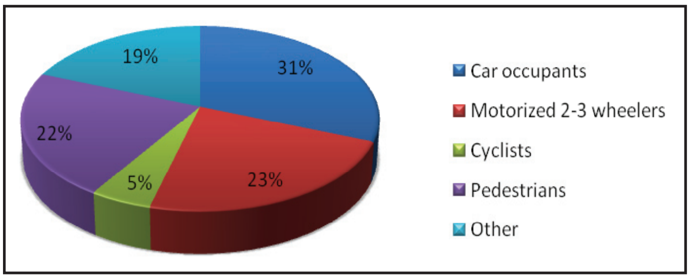

Fig. 1: Various Types of Road Users

In order to reduce the number of car crash Charles Birdsong, Peter Schuster, John Carlin, Daniel Kawano, William Thompson has designed Pre-crash detection system using ultrasonic, laser range finder and radar sensors. Advanced technologies are required to make these predictions and judgments correctly while also taking into account the drivers operation and behavior. Pre-crashsafety (PCS) system has been developed, which operates only when it is judged that a crash cannot be avoided by most drivers under normal driving conditions. Determining unavoidable crashes is restricted to a short time period immediatelybefore the crash, so as to improve the reliability of the judgment. In addition, the pre-crash safety system is made with a mechanism and system that will not place the driver and the running vehicle in an unsafe condition, even if the system is operated unnecessarily. In this paper, the Pre-crash Sensor is presented.

II. Pre-Crash Safety System

The Pre-crash Safety system reduces collision by estimating TTC (Time-To-Collision) to activate safety devices, which consist of "Pre-crash Seatbelt" system and "Pre-crash Brake Assist" system. The key technology of these systems is a "Pre-crash Sensor" to detect obstacles and estimate TTC. The pre-crash sensor, which is primarily composed of a millimeter wave radar and a computer for determining unavoidable crashes, recognizes an obstacle ahead and determines in advance whether a crash is unavoidable, based on location, speed, and course. The pre-crash seat belt, which employs a mechanism to retract the seat belt by a motor, reduces crash injuries through earlier restraint of an occupant. The pre-crash brake assist reduces the crash speed by quickly generating a large braking force in response to the driver's brake pedal application, even when sudden braking is not being performed. The Pre-crash Sensor uses millimeter-wave radar to detect preceding vehicles, oncoming vehicles, roadside objects, etc. on the road ahead. With respect to the obstacle a crash determination algorithm has been developed that takes into account estimation of the direction ofadvance of the vehicle, in addition to the distance, relative speed and direction of the object.

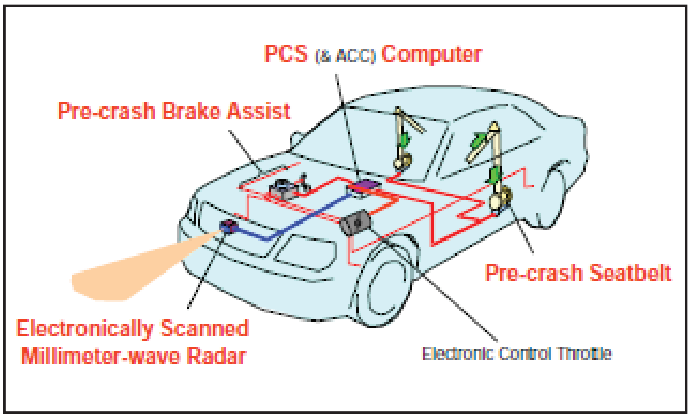

Fig. 2: Overlook of Pre-crash System

III. Concept of Pre-Crash Sensor

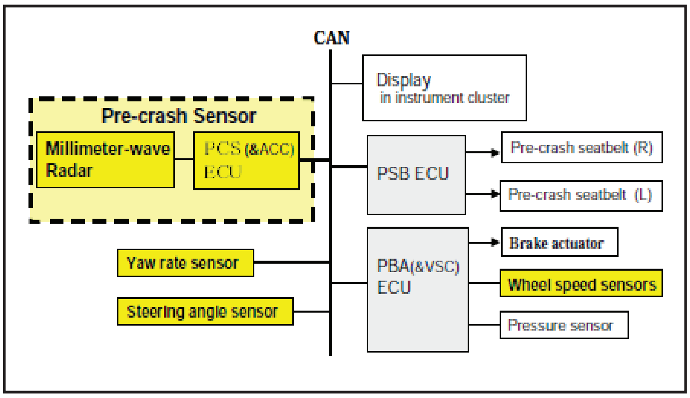

Fig. 3: Configuration of the Pre-Crash Sensor System

Distances to multiple obstacles such as preceding vehicles, on-coming vehicles, and roadside objects, as well as relative speeds and directions of the obstacles are detected by the millimeter-wave radar, while the movement of the host-vehicle is estimated by vehicle speed, steering angle, and yaw rate. The millimeter-wave radar, steering angle sensor, and yaw rate sensor are also used for Adaptive Cruise Control (ACC) and Vehicle Stability Control (VSC), to reduce sensor system costs. A PCS Electronic Control Unit (ECU) receives information from each sensor and makes decision regarding obstacles. The decision result is sent to a PSB (Pre-crash seatbelt) ECU and a PBA (Pre-crash brake assist) ECU and the final control of each device such as the pre-crash seat belt isexecuted by the relevant control ECU, such as the PSB ECU.

IV. Millimeter-Wave Radar

The millimeter-wave radar is robust which uses a phased array antenna for object identification purpose. The millimeter-wave radar consists of an antenna, a millimeter-wave circuit (T/R module) and a signal processing unit.

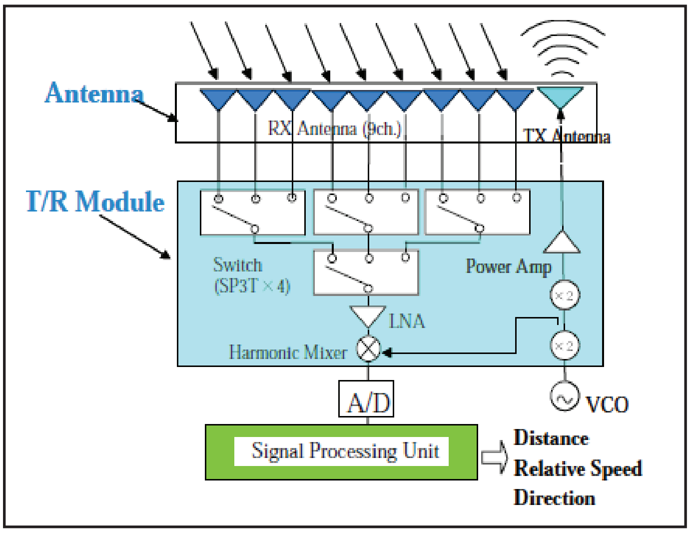

Fig. 4: Block Diagram of Millimeter-Wave Radar

The millimeter-wave radar systems used in PCS system are as follows.

1. Detection of the distance and relative speed: FM-CW system
2. Detection of direction: Beam scanning by digital beam forming (DBF)

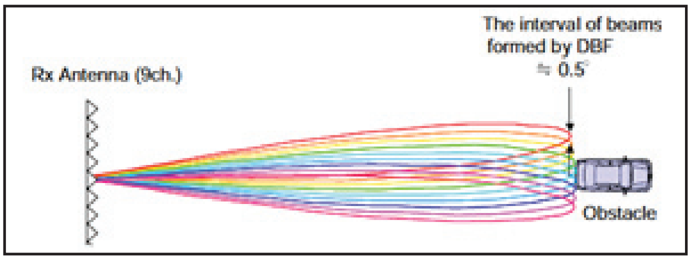

Fig. 5: Electronically Scanned Beams Using DBF (Digital Beam Forming) Technology

The specifications of the millimeter-wave radar used is mentioned below.

Item	Specification
Range	2－150m
Relative Speed	±200km/h
FOV(Interval of beams)	±10° (0.5°)
Calculation frequency	10Hz
Size	W107×H77×D53mm

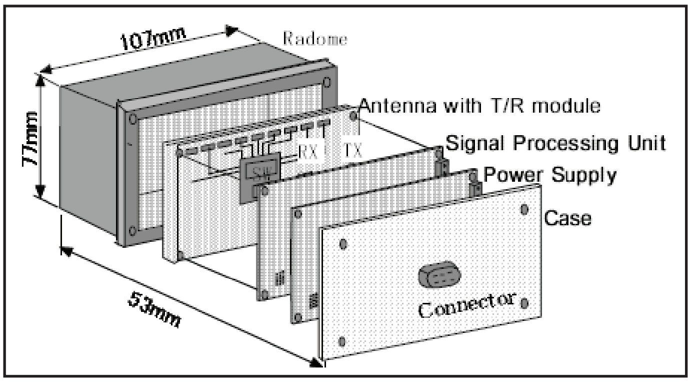

Fig. 6: Structure of Millimeter-Wave Radar

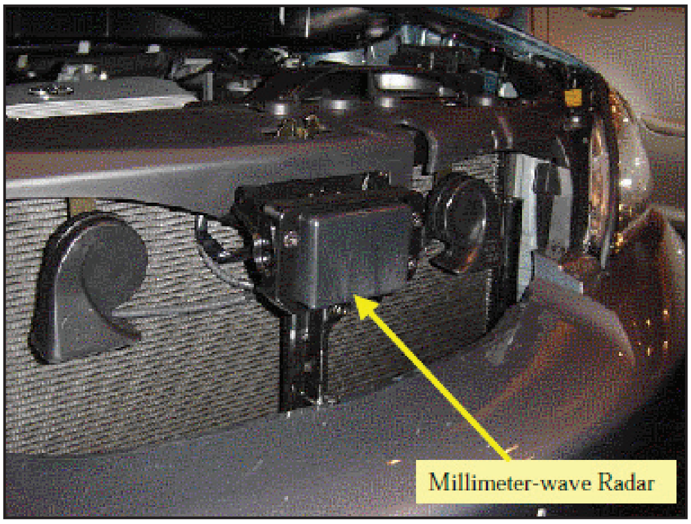

Fig. 7: Millimeter-Wave Radar Installed in a Vehicle

V. Obstacle Detection

The algorithm for obstacle detection is mainly composed of the two blocks shown below.

1. Determining whether an object exists either in the same lane or ahead of the host-vehicle.

Since the millimeter-wave radar is used for ACC, the ACC

algorithms for lane width and the probability that the preceding vehicle is in the same lane as the host-vehicle were applied.
However, the algorithms and constants for ACC (Adaptive cruise control), whose use is designed for use on highways and freeways, are not completely suitable for use with PCS (Pre-crash safety), and therefore some algorithms have been added and adapted for PCS. For example, in a case where a vehicle passes by an obstacle immediately before a crash (such as an on-coming vehicle at the entrance of a curve), simply making a judgment based only on information of the host-vehicle's lane will result in an unavoidable crash being determined.
Therefore, to prevent such erroneous judgment, the side position of the obstacle at the point when the crash is predicted to occur, obtained from the path of the obstacle, is added to the crash prediction algorithm. Furthermore, as with the case of ACC, a curve R, estimated by the steering angle sensor and yaw ratesensor, is used on estimation of the direction of advance of the vehicle. However, because the required response and the like differ from ACC, a correction method based on a curve R different from that of ACC has been added.

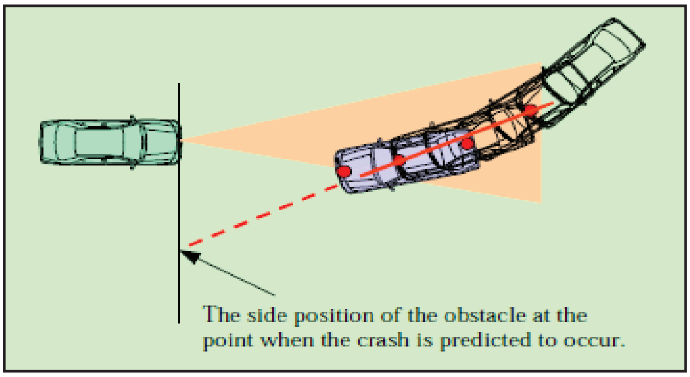

Fig. 8: Path Estimation of the Obstacle

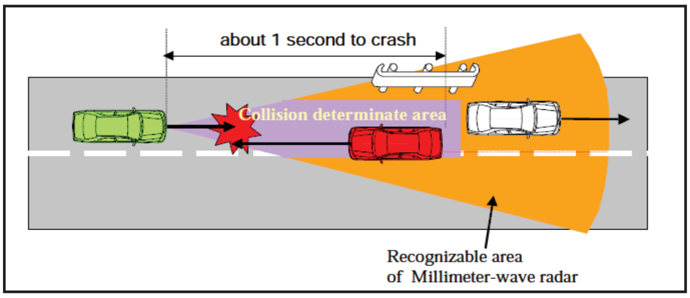

Fig. 9: Pre-crash Sensing Area

2. Determining whether the obstacle can be avoided by driver operation (braking and steering wheel operation).

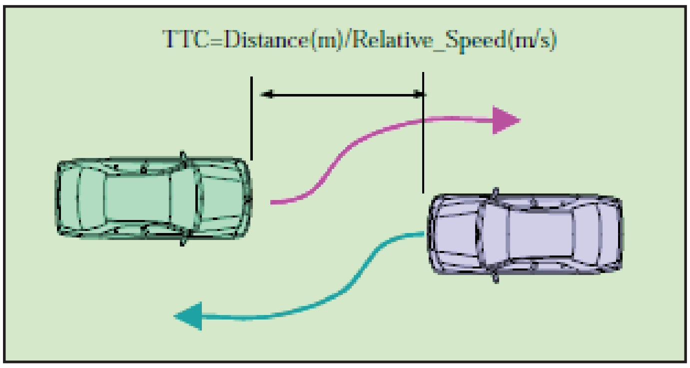

Fig. 10: TTC (Time To Collision) in which most drivers would not be able to avoid a crash even with a sudden avoiding operation

To determine whether a crash is unavoidable, the future crash-avoiding operations by the driver must also be anticipated. In this development, however, unavoidable crashes are determined based on a "time to collision (TTC)" in which most drivers would not be able to avoid a crash even with a sudden avoiding operation. When several obstacles exist, the obstacle with shortest TTC is judged as the top-priority obstacle for crash avoidance.

VI. Conclusion

This system aimed at reducing traffic accident injuries through application of active safety technologies in comparison to passive safety technologies such as airbags have long been attempted. Nevertheless, until now, sensor system performance has not reached a sufficient level, which has prevented commercialization of a system that detects actual obstacles in advance and activates devices for occupant protection before the crash. In this system a highly-functional, compact millimeter-wave radar that can be applied to the safety systems, crash determination algorithms that can determine an unavoidable crash more reliably has been developed.
As a result, the production of a system that activates safety devices before to an actual crash has been accomplished. Not many systems have these technologies yet, and this technological development may be just one small step, but it is probable that this is a step forward in the field of active safety. In the future, the crash injury reduction effect is expected to be further enhanced by constructing more advanced sensor systems through further research and work onMillimeter-wave radar performance and combine usage with an image sensor, as well as by increasing and upgrading application system.

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