Leading Change: The Transportation Electronic Revolution

Proceedings of the 1994 International Congress on Transportation Electronics

P-283

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Published by:
Society of Automotive Engineers, Inc.
400 Commonwealth Drive
Warrendale, PA 15096-0001
USA
Phone: (412) 776-4841
Fax: (412) 776-5760
October 1994

94C038

Collision Avoidance Technologies

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ABSTRACT

Studies have shown that more than 90 % of all traffic accidents are caused by driver error involving the recognition of the surrounding environment, errors in judgment, or poor driving habits. In this regard, automobile manufacturers have been developing technologies to increase the field of vision, to enhance the basic maneuverability of vehicles to ensure safe driving, and marketing such vehicles accordngly. Moreover, efforts to develop technologies to support the driver's recognition, judgement, and operation in a more positive manner are becoming increasingly active, in line with the recent intensified needs for safety, and advances in computation / information processing systems that have been developed over the past years. This paper provides an overview of the status quo of vehicle collision avoidance technologies, and discusses the technological and social issues for the practical applications of such technologies.

1. INTRODUCTION

Among the social issues considered recently in the automobile realm - such as air pollution, energy resources, fuel consumption, traffic congestion, recycle needs, etc. - the reduction of automobile accidents and enhancement of safety are the key issues that automobile users are most interested in. In order to cope with such issues, automobile manufacturers and governmental agencies (in concerned countries) have been implementing various measures to reduce traffic accidents, these measures have shown considerable positive effects.

Fig. 1 shows a trend involving the number of fatalities in traffic accidents that occurred in several countries, assuming that the number in 1970 is 100.[1] In each country , the number of fatalities was reduced, starting from the first half of the 1970s and extending throughout the1980s.

In Germany,especially, the number of fatalities was further reduced from the first half of the 1980s, while in Japan

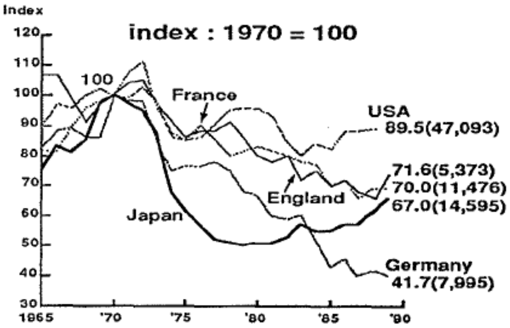

Fig.1 Number of Fatalities in Traffic Accidents

fatalities increased during the 1980s. A similar tendency is found looking at the number of fatalities per 100 million kilometers of automobile use, the number of fatalities was reduced drastically in the 1970s, and it has stayed nearly constant for the past several years. From the dramatic increase in number of automobiles, it is concluded that the development of new technologies for automobile safety, and the construction of a new traffic infrastructure are necessary for a major reduction in the number of future fatalities.

In the past, automobile safety technologies were developed with the primary focus on passive safety. A reduction in the number of casualties and fatalities can be expected from improvements in vehicle crashworthiness ,safety belts, and airbag systems. Therefore, automobile manufacturers are developing such technologies and governmental agencies are actively encouraging their use, which are showing some positive effects.

On the other hand,various types of developments have been made in the area of active safety to reduce the number of traffic accidents. Namely, technology was developed to ensure an adequate field of vision for driving, to increase the visibility of meters,and to simplify various switch operations.

Improvement of vehicle dynamic performance is also a key issue in the area of active safety. Along with improvements made in the basic performance of brakes and suspension systems, new functions have also been added by means of electronics, such as Antilock Brake System (ABS), Traction Control System (TCS), etc. Although it is difficult to determine the correlation between such active safety technologies and the reduction of accidents, they have proven to be an effective means of reducing driver workload, and preventing driving errors and the induction of such errors. In addition, steps have also been taken to improve the traffic infrastructure. The addition of traffic signals and their systematic control, street lights with higher intensity illumination, traffic information display panels, etc. have contributed markedly to the reduction of traffic accidents.

In this paper, present and future collision avoidance technologies are studied from the point of view of the driver's recognition, judgements, and operations and issues that deal with practical applications are discussed, including social problems. It is generally stated that more than 90 % of traffic accidents are caused by human errors. Fig. 2 shows rates of various types of human errors that cause accidents. [2] This figure illustrates that errors in recognition and judgment are major causes of traffic accidents. In the collision avoidance system, exterior environment sensors and information from the infrastructure are utilized to supplement human recognition, and judgment, and to automatically compensate for human errors automation directly to automobiles. The automobile driving environment is quite complex, which necessitates highly capable environmental sensors to properly collect information. As long as human beings want to drive automobiles at their own discretion, significant fluctuations are apt to occur in their driving functions. In order to attain a proper system of cooperation between human-beings and machines under such circumstances, we must not only overcome technological issues involved in the human machine interface (HMI), based on human factors,but also strive for the creation of social consensus and resolve the issues related to product liability, etc.

2. STATUS QUO& DEVELOPMENT TRENDS OF COLLISION AVOIDANCE TECHNOLOGIES

Table 1 shows the present status and development trends of technologies relating to preventive safety such as collision avoidance. Items related to safety include the acquisition of information from outside the vehicle, the methods to influence driver performance, and the means of monitoring driver and vehicle conditions. Items related to the monitoring of vehicle conditions will not be discussed in this paper.

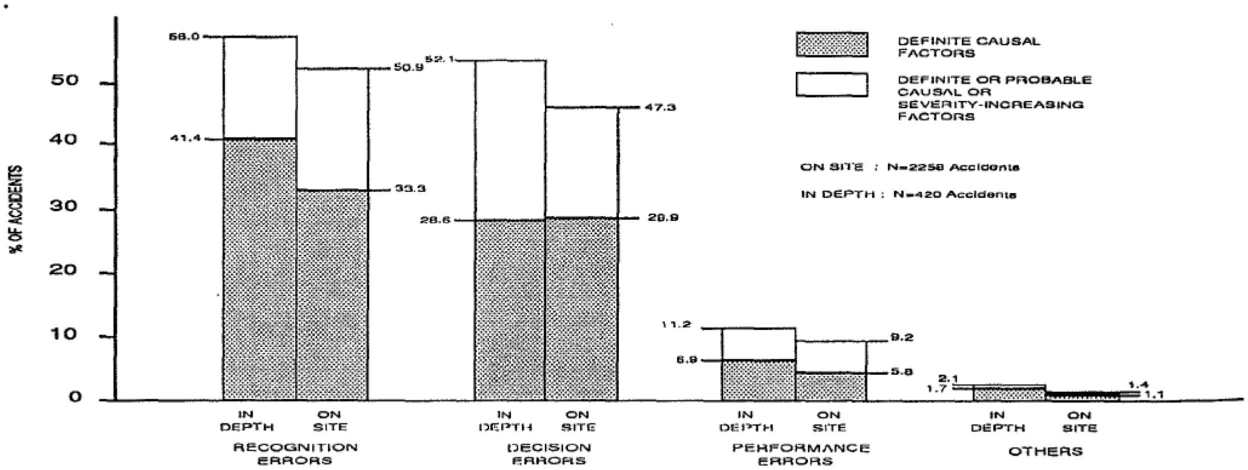

Fig.2 Percentage of Accidents in which Human Errors were identified as Causal Factors.

Such automation technologies used to eliminate human errors have brought about dramatic effects in various sectors of manufacturing. Semiconductor wire bonding and the mounting of electronic devices to printed circuit boards are good examples of the above. As will be discussed in this paper, however, it will be difficult to apply the scenario of

Technologies to assist recognition, judgments, and operations of the driver , as well as those to monitor his or her condition, are focused mainly on the relationships among the driver, the vehicle and the vehicle driving environment. The present status of safety related technologies will be discussed, using several preventive safety systems shown inTable 1 as examples of such technologies.

Table1. Status and Development Trends of Technologies related to Preventive Safety

			Already merchandised existing products	Products to be merchandised in near future	in research
Monitor, Warning and Assist Driving Performance	Assist Recognitions	· Forward Monitor	· High Luminance Head Lamp · Small Distorsions Windshield	· Night Vision · Light Control · Ultra Violet Lamp	
		· Sideward Monitor	· Clearance Sonar		
		· Rear Monitor	· Rear View Monitor · Back Sonar		
	Assist Judgments	· Abnormalities in Operations	· Laser Radar Collision Warning · SHF* Radar Collision Warning	· Lane Mark Deviation Warning System	
		· Risks of Collision	· SHF* Radar Blind Spot Monitor * Super High Frequency	· Lane Change Warning System	
	Assist Operations	· Supplementation	· Antilock Brake System · Traction Control System		
		· Automation	· Automatic Transmission	· Inteligent Cruse Control · Auto Brake	· Fully-Automatic
Monitor Conditions of the Driver		· Drunken Driving	· Breath Alchohol Ignition Interlock Devices		
		· Drug			
		· Drowsiness (Fatigue)	· Safety Drive Adviser	· Preventing Drowsiness using Image Processing to detect Blink	

2.1 Systems to Assist Recognition

Allowing the driver to accurately recognize his environment constitutes the basis of preventive safety. Basic technologies to provide accurate recognition ensure an adequate field of vision in the vehicle. That is, they are technologies to ensure appropriate locations of A, B and C pillars and a proper driving position (the position of eye point), and to optimize lights and the windshield wiping area. Ensuring the rear field of vision when the vehicle is backing up is one issue that may cause potential complaints, such as difficulty and uncertainty in operation, though severe accidents such as fatalities are not likely to occur because of the low speeds.

Fig.3 shows traffic accidents which occurred at night. [3]The number of fatalities occurring at night is about 30 % greater than the number in daytime. In general, the rate of accidents in rainy weather is about 3 to 5 times higher than that in good weather. They are presumably due to the lowered activity levels of the body and mind at night, and the decrease of recognition ability in the dark or rainy environment. Technologies to allow the observation of objects in such difficult visual conditions have been developed.

1) Rear View Monitor

Fig. 4 shows the specifications of Toyota's Rear View Monitor. The compact CCD camera installed at the top of trunk lid is used to show the rear view on the display when the vehicle backs up. This systems shows objects in the vehicle's blind spot, which is highly effective. Improvements are needed, however, in the following areas. 1. Distortion of images due to the wider lens angle , 2. visibility of objects at night, and 3. cost.

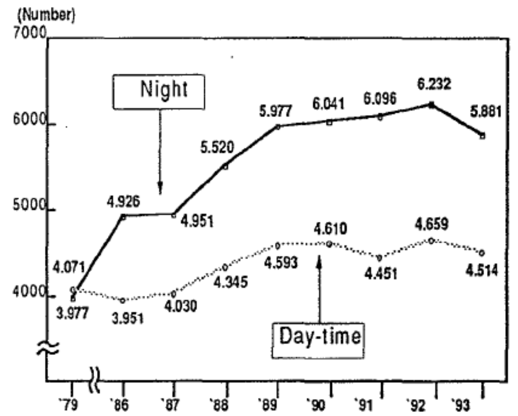

Fig.3 Number of Fatalities in Day and Night Condition

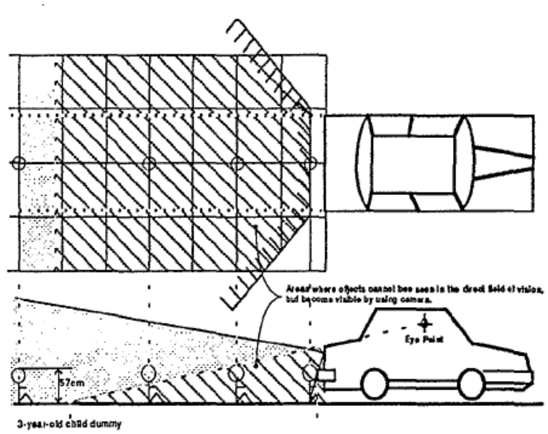

Fig.4 Rear View Monitor

The Back Sonar and Clearance Sonar are aimed at detecting the distance to each obstacle by means of ultrasonic sensors installed at the rear and corners of the vehicle, and informing the driver of the distance to the obstacle by changing the tone of the alarm according to the distance. Such devices are equipped on many vehicles(TOYOTA:PREVIA) in Japan, which are effective devices to assist drivers during parking maneuvers.

2) Light Control

Figs. 5 show the light control actuator developed by Koito. This system senses the presence of on-coming vehicles in the opposite lane, or vehicles operating ahead of the vehicle, by means of radars and infrastructure information, and controls the shade position properly so that the cutline (upper boundary of illumination) against such vehicles can be minimized to avoid glare. When the cutline control is done to a light of a fixed cutline, the distance to recognize obstacles within the vehicle's operating lane is doubled when vehicles are coming from the opposite direction, which makes it possible to increase the safety margin of drivers in making proper judgments and operations to avoid accidents.

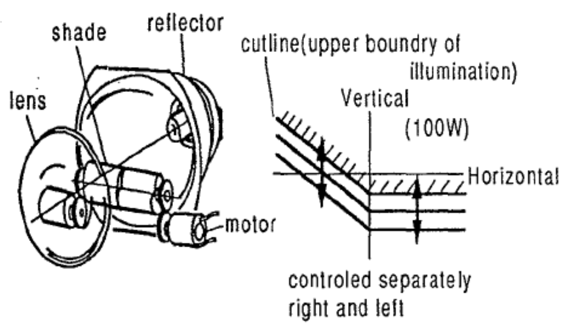

Fig.5 Light Control Actuator (Koito)

Volvo developed a headlamp which utilizes ultraviolet light. [4] It is capable of recognizing objects from a distance of 100 to 150 m, compared with a distance of 40 to 50 m in ordinary passing conditions, if such objects are fluorescent. Pedestrian's clothes (including jeans) made of cotton or nylon normally contain fluorescence. Therefore, it can effectively recognize pedestrians. Since ultraviolet rays have better penetration characteristics than visible light in severe environmental conditions such as rain, fog, snow, etc., the ultraviolet light produces excellent results in recognizing pedestrians, obstacles, lane markers, etc., which contributes to traffic safety. General Motors (Delco Elec.) proposed the use of an infrared camera , called Night Vision, as a system to supplement the normal field of vision at night.[5]

The effectiveness of systems to assist in recognition can be understood easily by drivers since they are extensions of measures to improve the field of view. For some of them , however, it is difficult to determine the direct effectiveness in reducing accidents, and costs of on-vehicle cameras, displays, light control actuators, etc. , are prohibitive. For these reasons, such systems have not been used extensively. When they are put into practical use, however, drivers of vehicles equipped with such systems would be able to recognize surrounding conditions, even in severe conditions such as foggy weather, and they may drive their vehicles at higher speeds than in a normal situation, which may cause a new safety issue. Therefore, developing products need to take into consideration not only technological issues , but also the potential for adverse effects on the entire traffic environment.

2.2 Systems to Assist Judgements

Various types of systems to detect and judge potential hazards caused by errors of drivers in recognition or judgement, and to warn such drivers by means of alarm devices, etc., have been proposed to induce drivers to drive safely.

1) Rear-end Collision Warning Systems

Fig. 6 shows the rates for different types of accidents for all of Japan. [6] For all of Japan, straight crossing path collisions account for the highest rate of about 28 % , followed by rear-end collisions, which account for about 24 % of the total. Fig. 7 shows the characteristic features of rear-end collision accidents which occurred on the highways. [7] In the case of highway accidents, however, rear-end collisions account for the highest rate of 37%. Since approximately 70 % of the rear-end collisions on the highways occurred on straight sections of the road, the drivers could have failed in recognizing of the state of the vehicle ahead. A proper measure to cope with this problem is not only to make invisible objects visible, but to alert the drivers to the presence of the objects, which is an area machines can handle relatively easily.

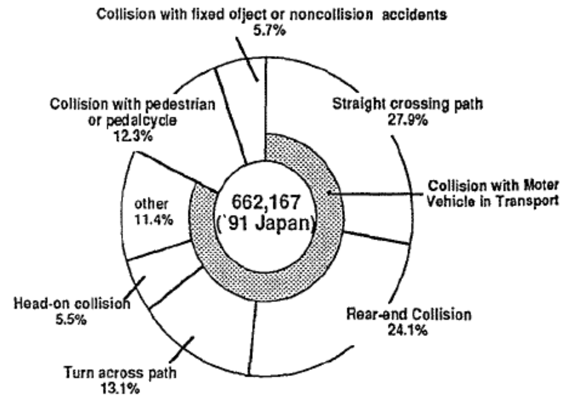

Fig.6 Rates of Different Forms of Traffic Accidents

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