

COLLISION AVOIDANCE SYSTEMS

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ABSTRACT

The topics discussed in the paper include the possible cause and type of crashes and the available technology to avert or reduce crashes. An attempt is made to explain the relevance and importance of the collision avoidance systems with respect to the existing conditions. Possible advantages and disadvantages of the collision avoidance systems are also discussed.

INTRODUCTION

Transportation is one of the most important economic activities of any country. Among the various forms of transport, road transport is one of the most popular means of transportation. Transportation has an element of danger attached to it in the form of vehicle crashes. Road crashes not only cause death and injury, but they also bring along an immeasurable amount of agony to the people involved. Efforts to improve traffic safety to date have concentrated on the occupant protection, which had improved the vehicle crash worthiness. The other important area where research is currently being done is collision avoidance.

Technological innovations have given the traffic engineer an option of improving traffic safety by utilizing the available communication tools and sophisticated instruments. Using sensors and digital maps for increasing traffic safety is in its infancy. Systems are being developed to utilize the available state of the art facilities to reduce or possibly prevent the occurrence of crashes. Total prevention of crashes might not be possible for now, but the reduction of crashes could easily be achieved by using the collision avoidance systems

BACKGROUND

The 1998 United States national crash statistics indicate 6,335,000 crashes. These crashes resulted in about 41,471 fatalities, 3,192,000 million nonfatal injuries and 4,269,000 crashes involving property damage only. On an average 114 persons died each day in a motor vehicle crash - one every 13 minutes. According to an estimate for reported and unreported crashes economic cost of traffic crashes in United States for the year 1994 was around \$150.5 billion (1).

Figure 1 below indicates that about 45 percent of the crashes that occur are caused by human errors. Human errors that cause crashes include failure to keep in proper lane, failure to yield right of way, inattentive, failure to obey traffic control devices, operating vehicle in negligent manner, drowsy driving, over correcting, driving wrong way and making improper turns. Some of these crashes may have been possibly avoided if the driver was provided with the real time information.

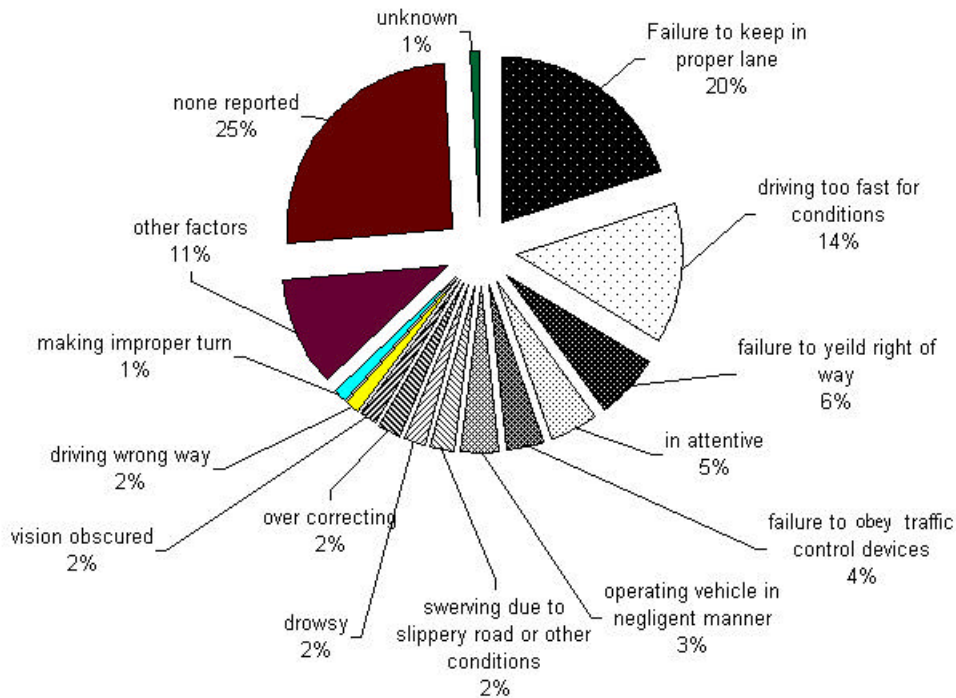


FIGURE 1 Factors Related to Fatal Crashes (1)

WHAT CAUSES A COLLISION?

The Indiana Tri-Level study found that driver errors are a cause for about 93 percent of the crashes (2).

Human errors that contribute to crashes include:

- Recognition errors

These errors include situations where a conscious driver does not properly perceive, comprehend or react to a situation. This type of errors may occur due to inattention, distraction and improper look out. These errors were found to be a definite/probable factor in 56 percent of the in-depth Tri-Level crashes.

- Decision errors

These errors include situations where a driver selects an improper course of action to avoid a crash. This might be due to misjudgment, false assumption, excessive speed, tailgating, and inadequate use of lighting and signaling. These errors were found to be a definite/probable factor in 52 percent of the Tri-Level crashes.

- Performance errors

These errors include situations where a driver selects an appropriate course of action, but commits a mistake when executing the action. These errors occur due to overcompensation, panic, and inadequate directional control.

Figure 2 shows some of the most common factors that cause a crash (2)

COLLISION AVOIDANCE SYSTEMS

The human errors related to crashes may be avoided if information is provided to the driver about the possible occurrence of a collision. Collision avoidance systems are technological tools that interact with the driver to reduce or prevent the occurrence of a crash by informing or warning the driver or by taking the control of the vehicle. The collision avoidance systems include driving enhancement tools like vision improvement, antilock brakes, obstacle detection and collision warning systems. Collision avoidance systems not only reduce the crash frequency, but also reduce crash severity (2).

Collision avoidance systems prevent a particular type of crash under a set of circumstances. Identification of major crash types, factors related to crashes and vehicle types are necessary to understand the possibility of crash reduction by the usage of collision avoidance systems. Figure 3 shows how a collision avoidance system works.

The collision avoidance systems may achieve traffic safety by preventing accidents altogether. According to one study, 60 percent of crashes at intersections and about 30 percent of head-on collisions could be avoided if drivers had an additional half-second to react (3). Collision avoidance systems will alert the driver of a possible collision in advance, giving him sufficient time to react. If the driver does not react to the information the collision avoidance system warns him of the impending collision. If still the driver does not react to the situation, the collision avoidance system takes control of the vehicle to avoid the collision. It is estimated that inattentive drivers are the cause of 75 percent of vehicular crashes (3).

Single vehicle roadway departure crashes and crashes into stationary parked vehicles account for about 20 percent of all crashes, but about 50 percent of these crashes are fatal (2).

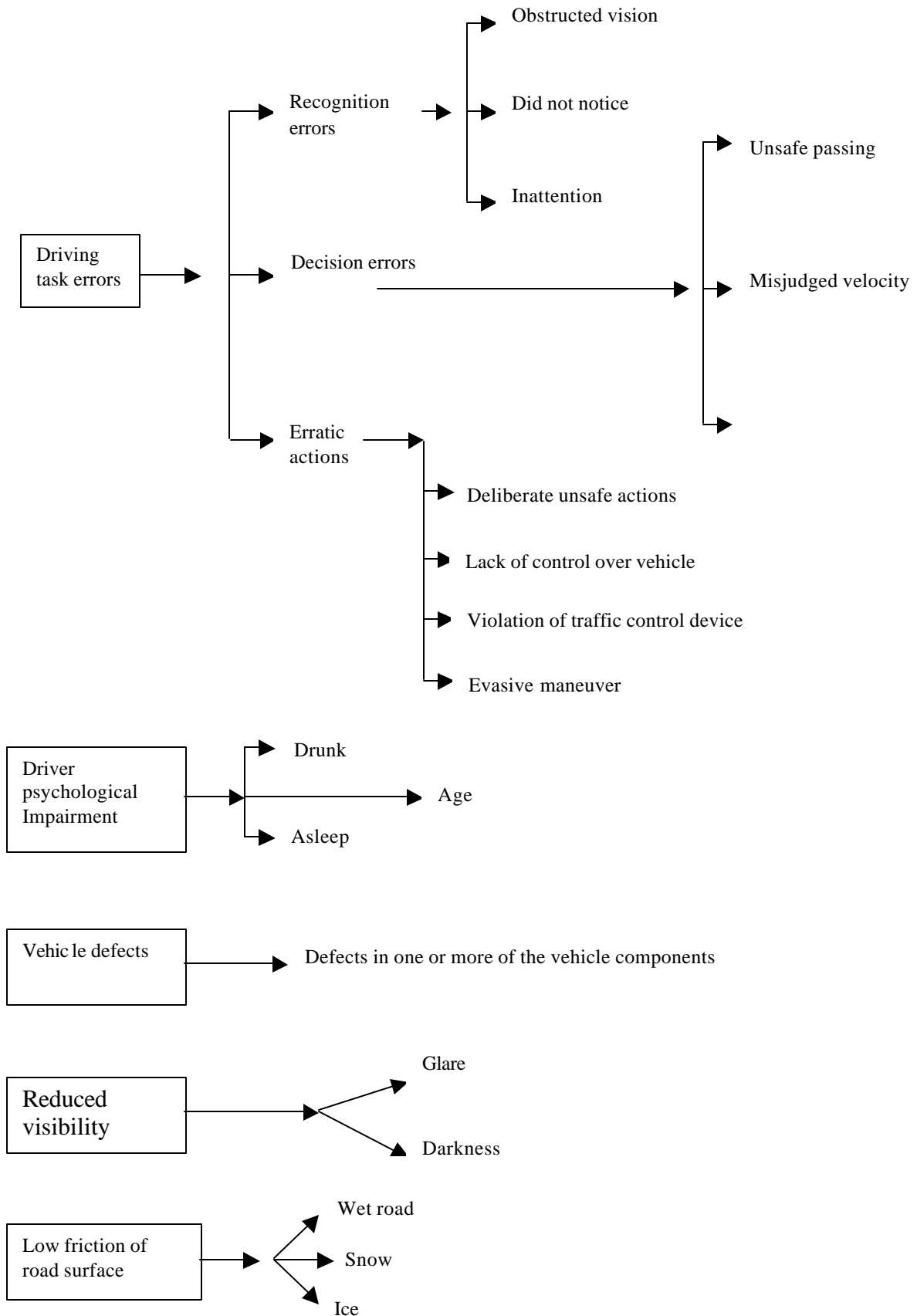


FIGURE 2 The Classification of Factors that Cause Crashes (2)

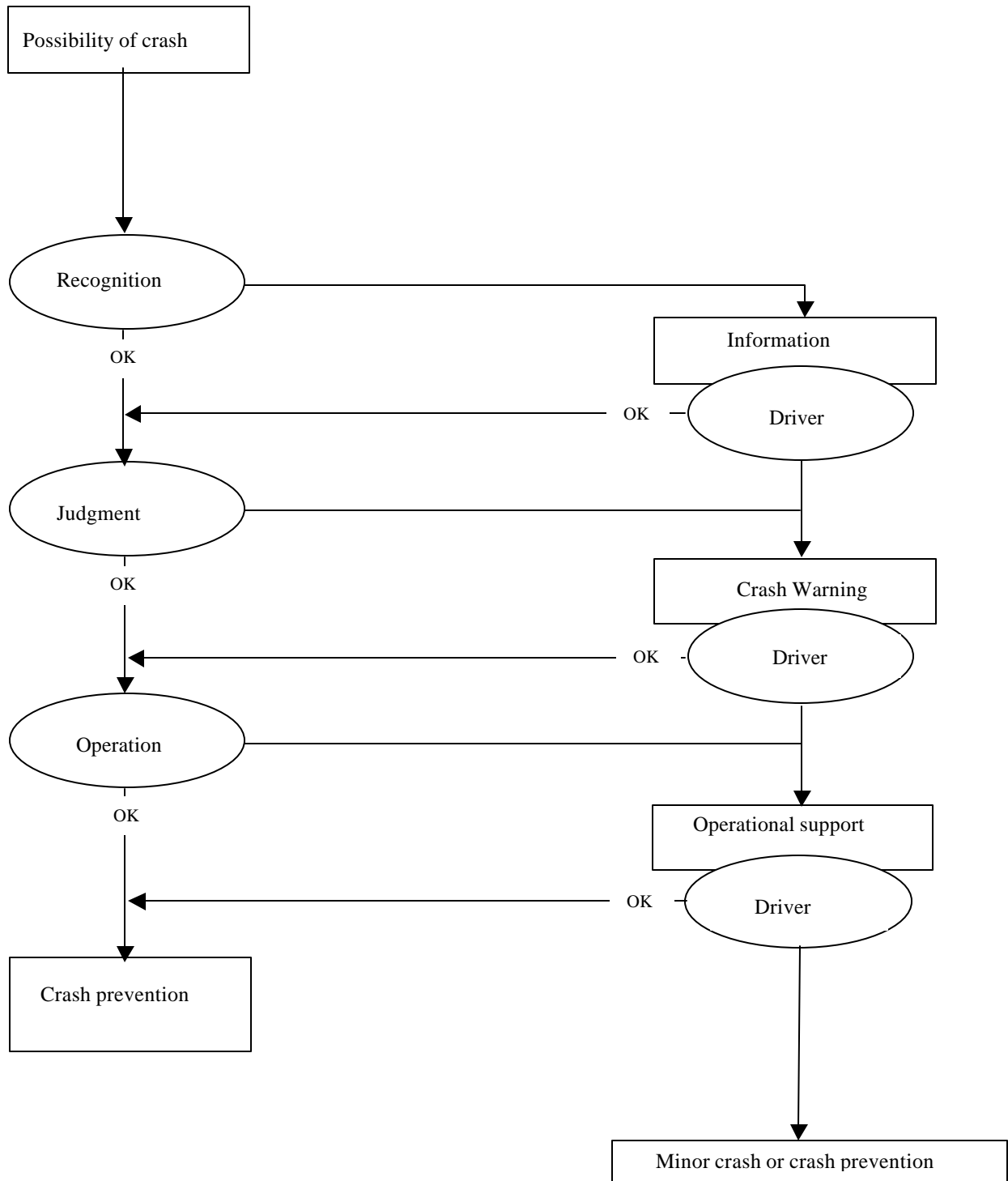


FIGURE 3 Crash Occurrence and Avoidance Process (4)

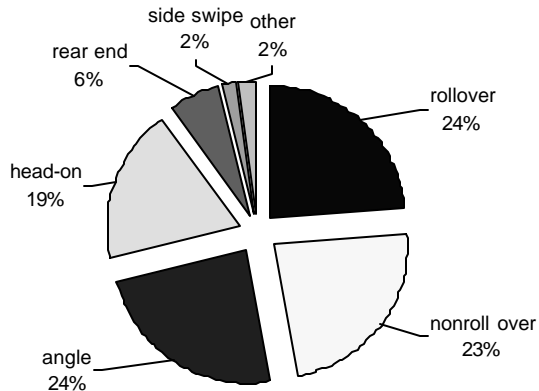


FIGURE 4 Occupant Fatality Rates Based on Collision Type (3)

From figure 4 it can be observed that the single vehicle roll over and angle crashes constitute for about 48 percent of the total occupant fatality, while the head on and rear end collisions contribute to 25% of the occupant fatalities. This indicates that if real time information is provided to the driver a major part of the accidents may be avoided.

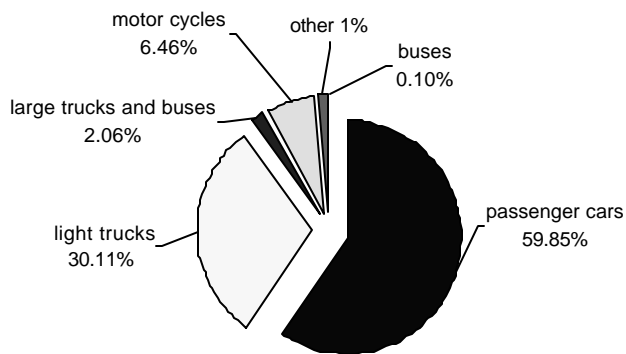


FIGURE 5 Occupant Fatality Rates Based on Vehicle Type (3)

Figure 5 indicates that the majority of occupant fatalities involve passenger cars. This shows that passenger vehicles equipped with collision avoidance systems would be more beneficial. The expected number of truck involvement's in crashes over the vehicle lifetime is more than twice that of other vehicle types, this is mainly due to their high vehicle miles traveled (2). It is estimated that a truck tractor on average has 60,000 vehicle miles traveled annually versus 10,000 vehicle miles traveled by a passenger vehicle (2). Therefore trucks are likely to need collision avoidance measures many times during their operational lives, which makes the installation of the collision avoidance systems in trucks more effective.

CLASSIFICATION OF COLLISION AVOIDANCE SYSTEMS

Functional Classification

Collision avoidance systems can be classified based on their function. They include the following types (2):

1. Advisory collision avoidance systems
2. Collision warning systems
3. Automated crash avoidance

Advisory Collision Avoidance Systems

These systems constitute information tools that tell the driver of the proximity of vehicles and obstacles within a specified distance from his vehicle. The interface could be either visual or auditory. These intelligent tools also inform the driver of the possible course of action to take to negotiate a steep curve, or a slippery surface or any other situation that requires his attention. These systems are designed to give the driver sufficient time to react to a situation that could possible occur. These systems also serve as sensory enhancement tools in reduced visibility conditions (2). Variable message signs come under this category.

Collision Warning Systems

These systems warn the driver of an imminent collision when the driver selects an improper course of action or takes no action to avoid a crash. The warnings are in the form of alarms. These systems require a correct and immediate response to avoid collisions (2).

Automated Crash Avoidance Systems

These systems are the most advanced systems that could prevent collisions from occurring. These systems include tools that take total control of the vehicle when the driver does not react in a necessary manner to prevent the collision (2).

Collision Avoidance Technologies based on Crash Type

Single Vehicle Road Departure

Single vehicle road departure occurs when the driver goes at an excessive speed in relation to the road environment, or due to reckless driving, or due to vehicle failure. Technologies to prevent these types of crashes include:

Driver Vigilance Monitoring This technology measures a driver's alertness by using steering wheel movements or by detecting the driving trace (2,4). The same technology is also used for lane departure warning. The driving trace is detected by using the signals from a vibration gyro sensor and a velocity sensor in the car navigation system. These signals are used to calculate a base line for normal driving. Horizontal deviation of the vehicle is estimated and if the estimated horizontal deviation exceeds a particular limit an audio warning or alert is issued (4). Figure 6 gives a graphical depiction of the driving trace technology.

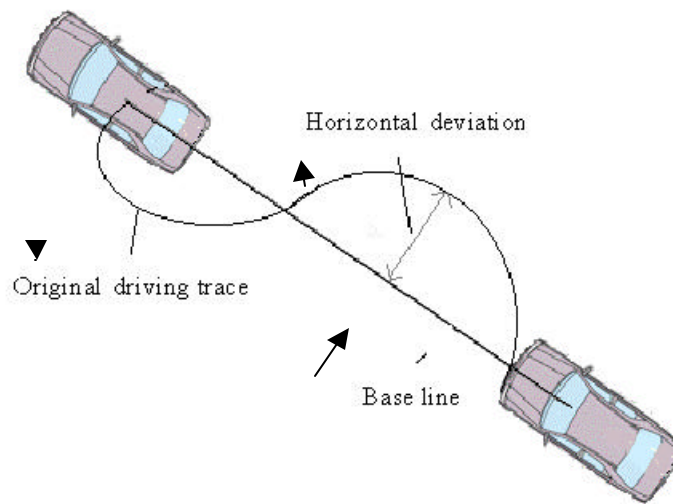


FIGURE 6 Maroon Zigzag Driving Detection Function (5).

Ice Warning In-vehicle warning devices or variable message signs can be used to warn the driver of a slippery condition on the road. Technologies to detect the presence of ice include in-vehicle tire and road friction monitor and roadside devices that measure air and ground temperature and humidity. These parameters are used to calculate dew point to determine the possibility of ice formation (2). If the calculations indicate ice formation, Variable message signs can be used to display the warnings automatically.

Vision Enhancement These technologies use infrared radiation sensors to detect moving objects and roadside features in low visibility conditions to provide the driver with an enhanced view of the road ahead (2).

Curve Approach Warning

Vehicle-to-roadside communications devices can provide in-vehicle warning by integrating vehicle speed and significant vehicle dynamics information with knowledge of road geometry either from a map database in the in-vehicle navigation system or beacon input provided on the curves. These curve-warning devices are used to complement existing road signs (4).

Rear End Collisions

Six percent of occupant fatalities in crashes that occurred in United States during the 1998 year were due to rear end collisions. Most of these collisions result from lack of attention and/or following a vehicle too closely, technologies to prevent the collision from occurring would include (2):

Headway Detection Systems Sensors to detect the presence and speed of vehicles in front of the vehicle would be utilized to provide advice regarding the safe minimum headway to be maintained. These sensors would also detect the presence of obstacles in the vehicle path and would provide the driver with warnings to minimize the risk of collision.

Adaptive Cruise Control This system is an application of headway detection system, which utilizes automatic braking to avoid collisions with vehicles in the lane of travel. Route guidance systems with enhanced map databases, and cooperative communication with the highway infrastructure can be utilized to set adaptive cruise control systems at safe speeds (4).

Collisions at Intersections

Driver inattention, deliberate violation and intoxication are the three types of human errors involved with the crashes at intersections. Advisory collision avoidance systems can prevent the occurrence of crashes that occur due to driver inattention.

Other Tools for Collision Avoidance

Anti Lock Brakes The objective of antilock brakes is to automatically modulate braking pressure to prevent the vehicle's wheels from locking during braking. Anti locks pump brakes automatically, many times a second, to prevent lockup and enable a driver to maintain steering control. Anti lock brakes prevent Locking of

vehicle wheels, which are the cause of longer stopping distances, skidding and loss of control on wet and slippery roads (6).

ADVANTAGES

Collision avoidance systems would reduce the number of accidents to a great extent. Accident reduction would also help reduce vehicle-hours of delay. According to the study conducted by Sullivan (9), around 40 percent of accidents occur in travel lanes, 10 percent on the median shoulder and the rest on the right shoulder. During congested periods an average accident can induce 500 to 1000 vehicle hours of delay (6). According to National Highway Traffic Safety Administration some of the collision-avoidance systems could prevent 1.1 million accidents in the United States each year and would save 17,500 lives and \$26 billion in accident-related costs (3).

“Greyhound Lines have installed systems on its bus fleet, which give collision warnings for the front of the vehicle and lane change warnings for obstructions in the driver's blind spot. As a result, Greyhound's accident rate fell 21 percent from 1992 to 1993”. (8)

According to a study the static and dynamic vision of people with age greater than 60 years is less compared to drivers below the age of 60 years (5). The percentage variations are found to be around 17.17 percent and 31.14 percent for static and dynamic vision respectively (5). The time required for the drivers with age greater than 60 years to react and apply the brakes is found to be 1.35 times that of the drivers with age less than 60 years (5). Vision enhancement devices and other simple collision avoidance devices could assist the aging drivers by providing them with more amount of time to react for a given situation. This could possibly help reduce collisions.

Simple collision avoidance systems that prevent backing collisions are available at low costs. These systems could help reduce the number of collisions that are very common in the parking lots.

DISADVANTAGES

These systems might produce false alarms, which might make the driver to discard the warnings. The frequency of the audio alarms has to be carefully designed so that it is not irritating to the driver. Increased speeds will reduce the headway and would increase the probability of a severe accident in the event of malfunctioning of a collision avoidance device. Some of these systems might make driver lose control over the vehicle, this would make the drivers dislike the deployment of collision avoidance systems. More extensive research in this area would help the engineers to design a foolproof system that is more reliable, economical and safe.

CONCLUSIONS

Collision avoidance systems if carefully designed would increase the situation awareness of drivers by eliminating or decreasing the human errors. These systems would bring about a major change in solving traffic safety related problems. Consideration of human factors in the design of the collision avoidance systems plays a very important role. Human centered design would make them more acceptable and useful to mankind.

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