ENHANCING VEHICLE SAFETY
WITH DROWSINESS DETECTION
AND COLLISION AVOIDANCE

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Abstract

Tremendous progress has been made with regard to
vehicle safety. Improvements in passive safety features
such as seat belts, air bags, crash zones, and lighting have
dramatically reduced the rate of crashes, injuries, and
fatalities. The fatality rate per hundred million vehicle miles traveled has fallen from 5.5 to 1.7. However, in spite of these impressive improvements, each year has more than three million injuries, around half of them leading to death and moreover many of these occur due to the difficulties we face in night driving. It has also been known that many of the car accidents are due to human errors. Fatigue and drowsy driving are two out of many which lead to a collision. There has been enough reason to assume that more automated automobiles help the driver from many undesirable routines of driving task. This paper is to show effective combination of different technologies to obtain optimized safety system in vehicles, mainly for night driving.

1 INTRODUCTION

Vehicles have been increasing in the world rapidly in recent times, and so is the number of accidents happening.

Every year the lives of more than 1.25 million people are cut short as a result of a road traffic crash. Between 20 and 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury, according to World Health Organization (WHO). A major portion of them occurs while night driving.

The introduction of automotive collision warning systems potentially represents the next significant leap in vehicle safety technology by attempting to actively warn drivers of an impending collision event, thereby allowing the driver adequate time to take appropriate corrective actions in order to mitigate or completely avoid the event. With this as an impetus, the Collision Avoidance System was launched.

The primary goal of this paper is to provide a highly focused effort to accelerate the development of active crash avoidance systems for the automotive industry due to human errors such as fatigue and drowsiness. Development of a comprehensive collision warning system, which is capable of detecting and warning the driver of potential hazard conditions in the forward, and side regions of the vehicle.
The system will incorporate the use of long-range radar or optical sensors that are capable of detecting potential hazards in the front of the vehicle in an event of the driver losing consciousness, an alarm system to wake up the driver and bring him back to consciousness short-range sensors to detect nearby objects when changing traffic lanes during an event of losing control of the vehicle (Fig. 3), and a lane detection system that alerts the driver when the vehicle is changing traffic lanes. The current systems effort is focused on providing warnings or implement a combination of any few technologies discussed here to the driver, rather than take active control of the vehicle and implementing it (Fig. 2).

A drowsiness detection system is particularly useful for night driving, to avoid accidents due to fatigue and falling asleep. It also helps in determining that the driver is not in an active state which could be a result of Fatigue, Drowsiness or any other serious medical issue (eg: Stroke, Heart-Attack etc.) It activates warning alerts to wake up the driver to prevent a possible accident and also alerts emergency services in a situation where the driver doesn’t wake up after a certain amount of time. Another difficulty faced while driving at night is bright beams of light from vehicles traveling in the opposite direction. A combination of sensors in the vehicles is used for automatic headlight dimming. This system will be capable of detecting and warning the driver of potential hazard conditions in the forward, and side regions of the vehicle. Conceptually illustrates the envisioned architecture for such a system. Information flows among the various system modules, from the sensing systems (i.e.: Forward Collision Warning (FCW), Side Collision Warning (SCW), vision, and onboard vehicle), to the Collision Warning Processing Module, and eventually the Driver-Vehicle Interface (DVI) which detects that the driver is not in an active state to render to the needs of controlling the vehicle. It provides appropriate warning and alert cues to the driver. Each of the sensing systems receives information about the Host vehicle states (such as vehicle speed) and sends appropriate parameters/information (such as on road traffic, appropriate lane path to take, detected vehicle speed and range, etc.) relative to the Host vehicle.
2 EXISTING RELATED TECHNOLOGY

2.1 Drowsiness and Sleep Detection Systems

The development of technologies for preventing drowsiness at the wheel is a major challenge in the field of accident avoidance systems.[4]. Sleep and drowsiness detection systems can be used to monitor the driver and alert the person to wake him up to avoid the possibility of collisions. There are different methods for this purpose. the onset of sleep is preceded by a drop in brain temperature as measured within the auditory canal. Auditory canal temperature is thus measured and its value used to detect drowsiness and activate an audible or visible alarm to prevent the subject’s falling asleep.[3] Other methods like monitoring rate of blinking the eyes, pattern of driver activity and heart rate can be used for the purpose. [4] Monitoring the rate of blinking of the eye, and head positions are reliable and are achieved by image processing.[4]

2.2 Automatic Braking System

Automatic braking is a technology for automobiles that sense an imminent collision with another vehicle, person or obstacle; and applies the brake to slow-down the vehicle without any driver input. Sensors to detect other vehicles or obstacles can include radar, video, infrared, ultrasonic or other technologies[1].

It uses sensor input to determine if there are any objects present in the path of the vehicle. If an object is detected, the system can then determine if the speed of the vehicle is greater than the speed of the object in front of it. A significant speed differential may indicate that a collision is likely to occur, in which case the system is capable of automatically activating the brakes (Fig. 1).

In addition to the direct measurement of sensor data, some automatic braking systems can also make use of GPS data.

If a vehicle has an accurate GPS system and access to a database of stop signs and other information, it can activate its auto brakes if the driver accidentally fails to stop in time.

Anti-collision systems using GPS will be highly effective with
2.3 Forward collision warning systems

Forward collision warning systems are an active safety feature that warns drivers in the event of an forthcoming forward collision. When the FCW system-equipped vehicle comes too close to another vehicle, a visual, audible, and tangible signal occurs to alert the driver to the situation (Fig. 2.) The main advantage of active vehicle safety approaches is they can determine distance directly [6]. However, active sensors have several drawbacks, such as low spatial resolution and slow scanning speed. [7]

2.4 Merging collision warning systems

Merging collisions can be reduced by adjusting relative Velocities and increasing the longitudinal inter-vehiclesSpacing. Since roadway capacity is proportional to vehicle speed and inversely proportional to longitudinal inter-vehicle spacing, a large reduction in speed or a large increase in spacing leads to a low capacity highway system. [8]
Figure 2: Collision avoidance system

Figure 3: Components of Collision Avoidance System
The system includes a direction sensor generating a direction signal corresponding a direction of motion of the vehicle, an external detector generating a detector signal corresponding to a location of objects outside of the vehicle, and a braking control system including at least two independently operable braking devices coupled to respective wheels (Fig. 2). [9]

3 PROPOSAL FOR ENHANCED SYSTEM USING EXISTING TECHNOLOGY

3.1 System Overview

The proposal is to combine Sleep Detection Technology, Forward Collision Warning System, Side collision warning system and Automatic Braking System to create a more efficient system for collision avoidance and safety in vehicles.

The system uses collision avoidance technology on detection of drowsiness of the driver, to allow the vehicle to switch lanes and move out of the main lane if the driver does not respond to alerts or warnings which are activated in response to the sleep or drowsiness detection. The vehicle’s hazard lights should also be activated this will alert other vehicles to take precautions.

All activated modules are reset manually as the driver is consciously awake and is found by the system to be fit to resume the journey. If in a situation where the driver does not respond to a certain amount of time which could be a result of some medical issues, the emergency services are alerted to the rescue.

Our Collision mitigating system uses radar and sometimes laser and camera to detect an forthcoming crash [10]. GPS sensors can detect fixed dangers such as approaching stop signs and turns through a location database. It can also send the current location details to the emergency services. Once the detection is finished, these systems either provide a caution to the driver when there is an forthcoming collision ahead or take action autonomously without any driver input (by braking or steering or both). Collision prevention by braking is appropriate at low vehicle speeds (e.g. below 50 km/h), while collision prevention by steering...
is appropriate at higher vehicle speeds. A fuzzy logic controller is used to decide whether to activate braking system or to drive away [1]. Application of dc-dc converters in electric car [11-20]

### 3.2 Functionalities of Different Modules

![Interaction of different modules.](image)

**1) Automatic headlight Dimmer:** The requirement of the headlight is very common during night travel. The same headlight which assists the driver for better vision during night travel is also responsible for many accidents that are being caused. The driver has the control of the headlight which can be switched from high beam (bright) to low beam (dim). The headlight has to be adjusted according to the light requirement by the driver. During pitch black conditions where there are no other sources of light, high beam is used to. In all other cases, low beam is preferred. But in a two-way traffic, there are vehicles plying on both sides of the road. So when the bright light from the headlight of a vehicle
coming from the opposite direction falls on oncoming vehicle driver, it glares and reduces his visibility for a certain amount of time. This causes disorientation of that driver. This discomfort will result in the involuntary closing of the drivers eyes momentarily. This fraction of distraction is the prime cause of many road accidents. It also voids him of his vision ability to a large extent as his pupil’s contracts to allow less amount of light to be absorbed and thus distorts his visibility. The prototype that is being discussed here is designed to reduce this problem by actually dimming down the bright headlight of our vehicle to low beam automatically when it senses a vehicle at close proximity approaching from the other direction. The entire working of the dimmer is a simple electronic circuitry arrangement which senses and switches the headlight according to the conditions required (Fig. 4).[5]

2) Sleep detection system: This uses the concept of measuring the temperature of the auditorial canal which reflects the temperature of the brain, which in turn reflects drowsiness. It also makes use of image processing to monitor the rate of blinking of the driver’s eye to detect drowsiness. On detecting drowsiness beyond a point (indicating that the driver could have fallen asleep), the system activates noise alert, attempting to wake the driver. If the driver does not respond in a certain amount of time, the system activates Automatic lane changing to move the vehicle to the side and park it there with hazard and noise alert turned up, until the driver wakes up and deactivates the system. The forward and merging collision systems together with the Automatic braking system ensures collision avoidance as the vehicle switches lanes and moves to the side.

3) Alerting The Driver(On Drowsiness): On positive detection of drowsiness, the system activated noise or vibrating alert to wake the driver (Fig. 3). It increases in intensity as it try to wake up the driver This can be switched off like an alarm (Fig. 3).

4) Alerting The Driver(On Forward Collision probability): The Anti-Collision avoidance system continuously gathers data about the host vehicles and object in host vehicles path. From this data, the Collision avoidance system determines that the host vehicle is in one of the following states.
State 1: Forward collision is not probable. Any alerts are deactivated.
State 2: Forward collision is probable. If no action is taken, the ACAS activates a noise alert.
State 3: Forward collision is imminent. This activates the visual alert and vibrates the steering wheel (Fig. 3). It activates automatic braking system.

5) Alerting The Driver (On Merging Collision probability): The Anti-Collision avoidance system determines if a vehicle is occupying the lane adjacent to a host vehicle. If there is a vehicle occupying the adjacent lane, the ACAS activates a noise alert (Fig. 3). The ACAS determines if the host vehicle is in one of the following states:

State 1: Merging collision is not probable
State 2: Merging collision is probable if Action is not taken
State 3: Forward collision is imminent

The ACAS activates an audible warning and activates automatic braking system.

6) Forward Collision Detection: When host vehicle is approaching another vehicle or non-vehicle obstacles too quickly and the collision is probable, the ACAS activates an audible alert. If the driver fails to respond or responds inappropriately, the ACAS determines that a collision is imminent. The ACAS activates the restricted steering system and vibrates the steering wheel, and activates automatic braking system (Fig. 4).

7) Merging Collision Detection: If the driver turns the steering wheel in the direction of the occupied adjacent lane, The ACAS determines that a collision is imminent. The automatic steering system steers the car in the opposite direction and a calculated amount braking is enabled so as to bring back the vehicle to safe state (Fig. 4).

8) Braking Control System: When the host vehicle is approaching another vehicle or non-vehicle obstacle with rapidly increasing proximity, if the driver does not activate the brakes, the system activates the audible alert and applies 40% braking for deceleration. If the driver still fails to respond, and the ACAS
determines that a collision is imminent, the braking control system activates the brakes completely (Fig. 1).

4 SYSTEM CONSTRAINTS

Every system has its constraints. These collective set of sensors do not readily provide lateral placement in the lane or discern lane and road boundaries. In the absence of lane boundary or roadway curvature information in the area ahead of the Host vehicle, it will be very difficult to reliably anticipate/predict:

(a) Changes in the roadway curvature (i.e.: curve entry/exit transitions),

(b) Differentiate between target lane-change maneuvers and curve-entry/exit maneuvers.

(c) Differentiate between Host vehicle lane-change maneuvers and curve-entry/exit maneuvers.

(d) Determine that roadside objects (i.e.: signs, poles, parked vehicle, etc.) which are located the curve-entry/exit point do not lie along the Host vehicle path.

(e) Identify if either the Host or target vehicles are hugging the edge of their respective lanes.

(f) Reduced protection in bad weather, including rain, snow, and ice as the sensor efficiency is reduced.

5 DISCUSSION ON OUTCOME

As we know, technology is growing at a very fast pace, and we can soon expect Modular Devices to be on the rise. Although substantial gains in knowledge of the Collision Avoidance systems was achieved during the program, there is more work yet to be done. System performance to cost trade-offs is a never-ending battle. The real world traffic environment is so varied that it is extremely difficult to make the system free of false alarms. In the future, the system development should take advantage of sensor fusion to increase its robustness. The future research for this system needs to focus more on determining appropriate scenarios for different drivers and circumstances. The global impact of
automatic collision avoidance on traffic flow is another issue to look more into. These systems are in a less mature position and need more research in various areas. Human factor issues while using this system is to be taken care, ignorance in not using this system so as to control the vehicle all be themselves often could result in fatal errors. Detection of driver alertness is a challenging task and will ensure timely and effective warning/evasive action.

For collision avoidance, more aggressive control actions might be needed. So in the control design operational limits of the vehicle and actuator saturations are additional issues to be considered. For collision avoidance, the brake or steering might operate close to their limits and therefore more accurate modeling of these components might be necessary.

Legal issues are serious considerations before this system can be widely deployed. Special research on the government side is necessary to remedy solutions which will encourage manufacturers in developing such systems. Moreover, guidelines and possibly standards can be devised by the government to regulate design of driver alert systems.

Therefore, the conclusion has been that with a robust automated system the chance of car accidents can be reduced. With the overwhelming increase in the number of vehicles on the road and increased chances for human errors are possible. Some kind of automation that would help to safely control the vehicle in absence of an active driver is very much needed. Many lives can be saved by implementing such a system, and also result in empowering a world were machines help in handling the human errors.

6 CONCLUDING REMARKS

The recent trend of research on the development of safety of vehicles was reviewed in this paper. The focus was on Sleep Detection Technology, collision warning and collision avoidance systems and their impact on drivers comfort, safety and traffic flow. The advances in Automatic headlight dimmer were also briefly investigated as they have a lot in common with the aforementioned vehicle-level safety systems.
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