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SMART VEHICLE AUTOMATION

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Abstract: This paper looks into the developments and trends in automation of vehicles which can control collision detection of vehicles. It is an attempt to provide a detailed research in this area. This paper explains the initiatives for automation in different levels of transportation system on vehicle level automation. Driver's comfort, increased safety is among the most important factors of automation. With reference to the analytical survey of the published research, this paper will try to provide a more clear understanding of impact of automation system on each of the above mentioned factors. The detail of sensory system requires dedicated paper due to its broad range and is not addressed in this paper.

Keywords: Automation Pedestrian AEB Operator sequence diagram Distributed cognition Complexity, Driver Assist System, collision detection, collision avoidance

I. Introduction

In the beginning of 21st century other advanced features collision warning and avoidance system were introduced into their products. However, there are many issues that need to be addressed before driving assistance system can be widely introduced in the future vehicles. The theoretical and experimental research on control issues is in a well developed stage. The main challenge in driver assistance system is the sensory issues. Today's technology has addressed many of the sensory issues with many still to be solved. The impact of automation on the driver necessitates an understanding of human factors in relation with the automated driving controls or assists. Research on human factor is very important and demands a lot more work. Legal and institutional aspects of automated vehicles are very important concern.

In the late 1980s and beginning of 1990s, state and private funded programs started more focused research in United States, Europe and Japan, to bring the idea of automated vehicles closer to reality. The main initiative was to improve the safety with automation. The very well organized and futuristic thorough research in this era, along with the rapid advancements in electronics and sensor technology, contributed to a more vivid understanding of the difficulties and potentials of such systems. Although the research in this period was focused more on

advanced highways, it later switched to intelligent vehicle initiative (IVI). While a lot has been said about improved safety and higher comfort level with automation in different papers, sometimes inconsistencies exist between different points of views on these matters.

II. Scope

This paper looks into the current research underway in certain areas of vehicle automation and their impact on comfort and safety. Collision avoidance and collision warning are the main focus of the paper. The paper should serve as the introduction for those who are less familiar with the subject. While it is not possible to cover the large number of publications in this area, the key findings of the research are included. The focus is on more recent literature. The paper does address the issues related to sensory requirements as it is a vast area and requires a dedicated paper that investigates them.

III. Vehicle Automation

While developments in crash control has led to vehicle designs (car) that are much safer in the event of collision, they cannot reduce the chances of a collision. Vehicle accidents still occur every day, the minor ones cause economical losses to the society and serious ones causes injuries or loss of lives. Rear-end collision, for example account for approximately 1.8 million crashes annually. More strict traffic regulations and safety standards can be helpful in preventing the accidents to a certain degree. Many accidents can be avoided if the human driver limits can be overcome by automating some parts of the driving tasks with safety initiatives. This initiative has encouraged extensive research in collision warning and collision avoidance system.

The Collision warning system can warn the driver of an imminent collision. Statistical accident data show that a considerable portion of accidents is caused by driver's delay in recognizing or judging the "dangerous" situation. In forward collision, for example, it is claimed that if an extra half a second of warning time is provided to a driver, 60% of collision can be avoided and with one second of warning time it increases to 90%. Therefore, it is believed that providing some sort of appropriate warning to the driver can help reduce the probability and severity of vehicle accidents. Car companies are involved in major research plans to implement Collision Warning System, which can increase safety. Major regulatory state agencies are also interested in this area to improve safety on the roads. Collision Warning System has been in practice in commercial heavy truck fleets and buses in the United States for a few years now and has been very successful A more futuristic measure to prevent collisions is a collision avoidance system that can perceive the dangerous situation and automatically control the vehicle out of danger. When the driver fails to perform the necessary emergency maneuverer, a collision avoidance system will take the control and brakes and/or steers the vehicle to avoid a collision. The control paradigms that can perform slight emergency manoeuvres are in an acceptably developed stage. However, more robust situation-recognition systems are required before such systems can find practical use in every vehicle. Very robust and reliable sensory system is essential for reliable operation of the system. Liability issues are again more important for collision avoidance systems as they can potentially overrun driver's decision and result in some unforeseen scenarios. Therefore liability issues are stronger challenges than technical barriers.

In the following sections, control issues, human factor concerns and liability are discussed in detail. Sensory requirements need dedicated publications and are not discussed in this paper.

IV. Vehicle Automation Control Scheme

The most researched area in vehicle automation is the control methodology. Once the sufficient information is gathered about the state of a vehicle with respect to other vehicles, a control scheme is required to either assist the driver in controlling the vehicle or autonomously control the vehicle itself. In automated systems, the higher level controller determines the desired motion of the vehicle for lower level controllers which control the engine, brakes, steering etc. therefore design of the higher-level controller requires a good understanding of the vehicle environment. Design of the lower level controller requires a good model of the vehicle itself.

A. Higher-level Controller

While lower level controllers are very similar, the differences in control design are reflected more in higher level control design. Higher eve controller processes the inputs from the driver, the infrastructure, other vehicles and the on board sensors and sends the appropriate commands to the brake and throttle control. Mass of the heavy duty vehicle can vary considerably in different loading scenarios and mild road grades can be serious loading for a heavy vehicle. Good estimation of mass and road grade can improve the performance of the higher level controller by reducing the chance of issuing infeasible control commands. The proper spacing is mostly determined by human factor issues which will be discussed later in this paper. Once the desired spacing or velocity is determined, the higher level controller calculates the desired acceleration that smoothly and quickly reduces or increases the spacing or velocity to their desired values. To imitate human behaviour f*uzzy* or neuro controllers can e trained for spacing adjustments as suggested in. However many higher level controllers are based on mathematical models. For example, application of non-linear control schemes [32] and optimal dynamic back stepping control.

The more challenging problems of automation emerge when the impact of such automation on the drivers of the involved vehicles is being considered. Section IV elaborates on the human factor side of automation.

V. Human Factor Issues

Goodrich and Boer [68] categorise driver assist systems into driver assist systems that are initiated by the driver to safely promote comfort and assist systems which are initiated by the system to comfortably promote safety. Human factor studies play a major role on the successful implementation of both types.

The driver is responsible for supervision of the automated tasks in advanced automated driving assist. The assist system normally relieve the driver from some routine physical tasks in driving, for example, maintaining a steady headway from the preceding vehicle.

Designing a collision avoidance system is bit complicated as it is the system responsible for monitoring driver's actions or consequences of such actions and to identify if a collision avoidance maneuverer is necessary. A collision warning system has the additional responsibility of communicating the situation to the driver so the driver can take timely and safe action. A very good understanding of driver's psychology and behavioural habit is therefore necessary. The research should determine the baseline human driver behaviour and then evaluate the affect of different designs on driver's work load.

Human factor issues are not exclusive to driver assist systems. Many sectors of technology conduct Human Factor research for their products. Test results for identifying human driver's driving habits are available and could be used to establish a baseline for performance of the

driver-assist system. Timely and accurate determination of driver alertness can increase the safety and improve reliability of system by reducing false alarms.

VI. Legal Issues

The discussed driver assist system can improve the safety but may change the character of vehicle accidents. Therefore, there is a possibility that cost of liability insurance for the manufacturers might discourage the rapid growth of driver assist system. The available published research reports that analyse the legal and institutional difficulties of driver assist systems are very few. The few existing reports and papers mainly discuss the legal issues of automated highways rather than vehicle level automation. Syverud explains how different driver assist information system might shift the liability distribution toward the manufacturer, he proposes the techniques that manufacturers can use to reduce the liability costs without massive tort law reforms.

1. Providing product warning;
2. Recording and documenting the performance of assist system;
3. Buying liability insurance covering the warning system;
4. Having an independent producer/installer with fewer assets produce/install the system after the vehicle is purchased by the consumer;
5. Persuading the state legislatures to enact laws that failure of a warning system cannot be used as a defence in a negligence suit;
6. Cooperating with federal agencies in implementing driver warning systems in accordance with guidelines promulgated by federal government.

There are common/particular interests between the government agencies, private companies, academic and research institutes in advanced vehicle control systems. The government agencies are more interested in increased road safety and improved traffic condition.

VII. Conclusion

In this paper the recent trends of research on development of driving assist systems was reviewed. The focus was on collision warning and collision avoidance systems and their impact on driver's comfort, safety and traffic flow. The vehicle based assist systems have few barriers to pass before they can be used widespread. The benefits and deficits of such systems are not completely understood yet. The ways in which Automatic Collision Control systems can improve the driver's comfort and the different viewpoints of the safety are discussed. A safe and comfortable design requires longer headway between the vehicles. Abiding to this , design will decrease road capacity. Collision warning and avoidance systems have the added complexity that they should be able to recognize a hazardous situation and communicate it to the driver. The human factor issues are of great importance and therefore a section in this paper was dedicated to this subject. This review of the research on driver assist systems, collision warning and avoidance systems, provides a convenient way of evaluation of the recent research advances in the field. It serves as thorough reference for researchers and engineers in automotive engineering and will also be an introduction for those who are less familiar with the subject.

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