Intelligent Information Systems in Modern Cars: The Future of Road Safety

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Abstract

Intelligent Information Systems are becoming beneficial items in modern cars which increase the potential of higher road safety. This article presents 8 features of Intelligent Information systems in modern cars and also presents the trend of Information Systems in the near future. The summarization of the significances and the contributions of those current and future road safety Information Systems will be mentioned in the conclusion as well.

Keywords: Information Systems, Modern cars, Road Safety.

1. Introduction

Road safety is one of the most critical issues in today's modern life style. The World Health Organization reported that "Worldwide, an estimated 1.2 million people are killed in road crashes each year and as many as 50 million are injured [1]." The common causes of most vehicle incidents are collisions with another vehicle, car equipment failure, pedestrians, poor roadway, obstructions in the road, and driver behavior [2]. To gain a better idea of potential road safety improvements, previous research must be looked at closely. The goals are to studying and discover ways to avoid car collisions, also ways to alert drivers of unforeseen hazards in the road. Information Systems can help archive these goals, the well-defined computer science field is evolving toward a new scientific area of study which includes people, procedures, data, software, and hardware. In general, information systems in conjunction with road safety will eventually be necessary for drivers to continually increase the awareness of drivers via new technology and devices. Many systems have already been installed in modern cars. These systems not only show useful information to enhance drivers' usability but also to inform him or her of what happen and what options are offered to overcome any problems or delays, which in turn reduces potential traffic accidents. This paper presents some of the latest active information systems within car manufacturers and some relevant researches involving developments of road safety in a modern car industry today. Moreover, a quick look at trends of systems in forthcoming years.

2. Features of information systems in modern cars

Several types of the information systems are being introduced into new cars from factories, also customers have a wide variety of aftermarket hardware to choose from. These are useful and provide various types of information services to assist drivers in avoiding traffic collisions or to mitigate them. The lists and details of current features are as follows;

2.1 Car Information Systems

Car Information Systems provide information from inside and outside the vehicle to the driver. Nakamura, et al. [3] describes the ITS (Intelligent Transport Systems) Car Information System as a concept of information providing a service center to vehicles. The idea was to install an information processing system in a car which would provide information services to the driver from various types of exchanged information between systems inside and outside the car via telecommunication and broadcasting. Most systems involve calculations of vehicle locations using GPS (Global Positioning System) and displays the position of that location and the destination with electronic maps. Also, the system employs a variety of outside services to provide traffic information such as the telecommunications, broadcasting and an in-vehicle data bus to allow the exchange of information among various devices inside and outside the car. At the same time, it also offers some additional information services to the driver as well. Figure 1 shows the concept of the ITS Car Information System.

A part of the Car Information Systems is an automotive navigation system. The system computes position data to locate the driver on the road from the unit's map database. This generates directions to locations according to its onboard database [4]. In General, Navigation systems displays information in terms of visualization and audio. A GPS navigation device seems to be a standard item in today's market place. It is a good example of hardware and software working together to assist the driver with daily travel. To enhance the performance of navigation systems, currently, there are many car manufacturers improving this particular

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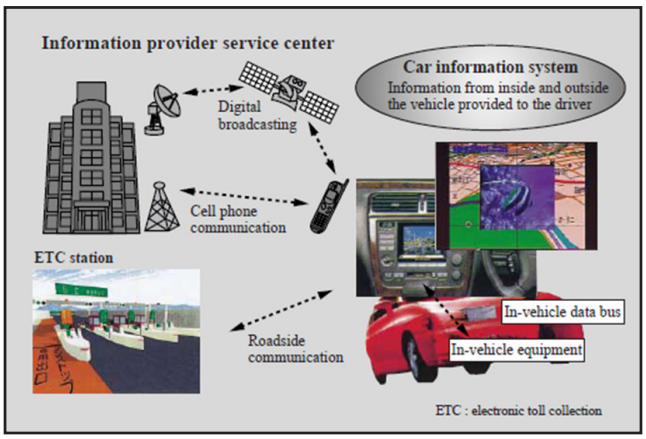

Figure 1 *The ITS Car Information System [3].*

system to the next level. BMW is one of the car manufacturers who are currently developing a new navigation system which is called the Intelligent Learning Navigation System or ILENA. The system will record and learn the driver's driving habits. The particular driving pattern will be adapted with the destination based on the previously registered data in order to increase the efficiency of your journey. This aims to record road conditions, elevations, and curves in an attempt to save fuel efficiently. [5]

Figure 2 *Navigation System in a BMW [5].*

2.2 Lane Keeping Assistant System

Whenever a car leaves its lane unintentionally, it is a risk to other vehicles. In six serious accidents on German roads, more than a third involved in this type of accident were killed [6]. To avoid this particular situation, a new information system to assist drivers to keep driving in their lane has been developed. Using the idea of forward-looking safe monitoring to warn drivers before an unsafe situation occurs is the aim. This can be accomplished by using a combination of functions. A camera on the inside of the windscreen will monitor the road and the line markings at the same time. When the car leaves its lane, the system will warn the driver [6]. Theoretically, leaving a lane unintentionally could be caused for several reasons. Studies have shown phone-use is related to driver distraction which leads to drivers inability to keep a proper lane position, also lane deviation can be caused by tuning the radio, answering mobile phone calls, and recently texting messages from a mobile phone which completely distracts the driver as it requires not only one hand but also movement of the driver's head [7], [8]. Moreover, according to the above reference, distractions from inside the car are more susceptible than outside the car, Lam [9] implied that there are two basic categories for visual focus, the road scene and the interior. Therefore, Pohl, Brik and Westervall [8] presented an idea to assist the driver to keep in lane by judging the driver's distraction levels. Their approach makes use of the driver's face vector which in principle is the direction of the driver's nose tip, and eyeball detection. In their system, the basic layout of the entire system is combined by three components, 1) the distraction modules 2) lane-keeping module and 3) report to an intervention module. The processes start if the vehicle departs from the lane and the driver is detected as distracted, then an intervention is triggered which sends a warning to the steering wheel.

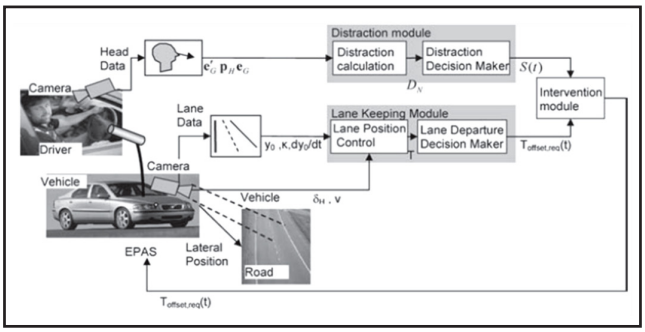

Figure 3 *A model of driver-distraction-based lane-keeping assistance system [8].*

Mercedes-Benz has also developed a Lane Keeping Assistant System. Unlike the tradition systems that only focus on the outside of a car such as the road line, Mercedes-Benz's system assesses the driver's actions together at the same time. The system can ascertain reliably whether the car has left its lane intentionally or unintentionally. The image-processing system will send data to an electronic control unit, where it determines the position of the car. The system warns the driver in a timely manner and prompts them to counter-steer by activating an electric motor, this makes the steering wheel vibrate with a series of short vibrations when it determines that the car is leaving its lane unintentionally. Moreover, the system will not activate a warning if the car leaves its lane intentionally, for example if the driver accelerates before

overtaking or leaves the lane or moves back into the original lane after overtaking. In addition, if the driver uses turning indicators before leaving the lane no action is taken [10].

Figure 4 A Lane Keeping Assistant System in Mercedes-Benz new S-Class [10].

The different approaches of Pohl, Brik and Westervall's system to the Mercedes-Benz's system is they focused on face, nose tip and eyeball detection of the driver. Whereas, Mercedes-Benz focused on responding from the drive such as not using the turning indicators, acceleration before overtaking and/or leaving the lane [9], [10].

2.3 Braking Assistant Systems

2.3.1 Automatic Braking System

Rear-end collision scenarios are the most common type of accident, commonly caused by distracted drivers not reacting in time. Thus, an Automatic Braking System has been designed to stop car collisions with other cars, people, obstacles, or even to slow down the car when approaching stop signs. The system will respond and slow and/or stop the car without input from the driver. Basis function for this system uses sensors to detect other vehicles or obstacles, via radar, video, infrared, ultrasonic or other technologies. A GPS sensor with a location database which includes stop sign locations, detects stop signs when approached. [11], [12], [13]. The system is not only to prevent car collisions but also to reduce the speed of collisions. Sometimes, a collision cannot be avoided, the idea of these particular scenarios has been realized by many car manufacturers. Given the example of information systems for automatic collision warnings and controlled braking systems, Volvo is another car manufacturer who has invented an innovative technology to help assist drivers to avoid potential collisions and reduce the potential impact speed when the rear-end collision scenario arises [14]. The system uses the forward-sensing wide-angle camera fitted in the front of the interior rear-view mirror to continuously monitor the road using a long- range radar. Both radar and camera will detect vehicles in front of the car within the long-range radar radius of 150 meters in front of the car while the camera range is 55 meters. The data fusion of combining information from a radar and camera are transmitted to the control unit which helps the system to become more efficient. When obstacles are detected (even moving objectives) the system will show a flashing red warning light in the head-up display on the windscreen, also a sound will be activated at the same time. If the driver does not respond and apply the brakes to slow down, the braking system will automatically engage to slow down the car. Volvo designed this particular system to avoid impacts entirely or to reduce its impact speed, thereby reducing the risk of injury to the driver, passengers and pedestrians from serious injuries [15].

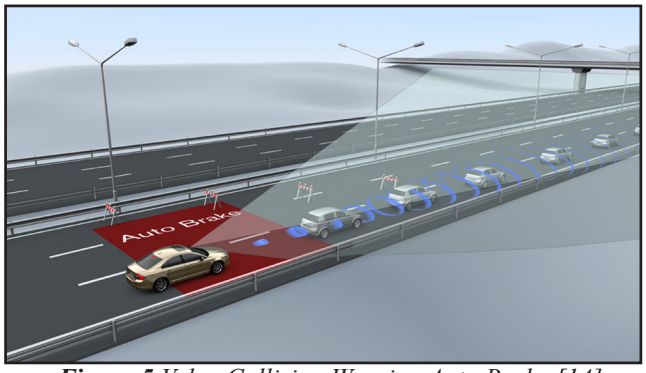

Figure 5 *Volvo Collision Warning Auto Brake [14].*

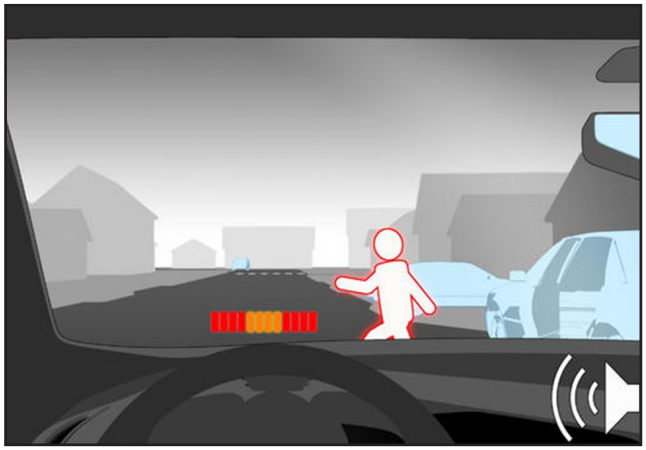

Figure 6 *Warning Auto Brake signal [15].*

This particular system has also been applied to the Japanese domestic market (JDM) cars for example, Honda has developed CMBS (Honda's Collision Mitigation Brake System) and it was first introduced on the Honda Insprie in 2003 [16]. The system uses a radar-based system to monitor the situation ahead and control barking automaticly if the driver does not apply brakes also the warning signal will be illuminated with tightening of the seat belt.

As part of the efforts to ensure safe driving on the road, Toyota Motor Corporation has announced the new auto braking system which involves advanced GPS (Global Positioning System) technology for accurate position monitoring of vehicle braking systems to work automatically. It will recognize stop signs at intersections and then alert users with both audible and visual warnings and eventually apply sufficient brake power to avoid any vehicle collision on the road. This is a slightly different concept compared to the Pre-crash safety system developed by this giant automobile maker before but with the same purpose [17].

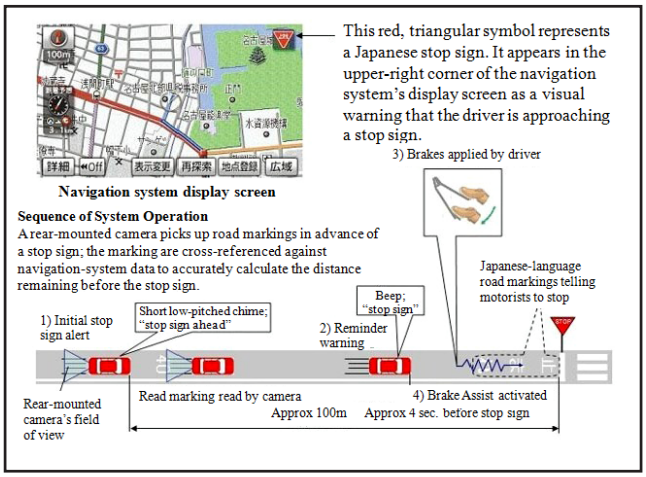

Figure 7 *Toyota Automatic Brake System Assisted by GPS Technology [17].*

2.3.2 Braking Bag Systems

The concept of an airbag has already been implemented in modern cars very effectively. Those airbags are to protect the head, thorax, and knees of the people in the car. However, this braking bag system helps the drivers to reduce power when breaking before a head-on crash. Braking Bag Systems are another innovation of brake assistant that has been developed by Mercedes-Benz [18]. This particular system is now fitted to the Mercedes-Benz ESF S400 Hybrid (Experimental Safety Vehicle). Unlike traditional systems such as ABS (Antilock Braking System), TCS (Traction Control System) and ESP (Electronic Stability Program), the highlight of this new brake assist system uses braking bag technology. The ideas uses an external airbag which slows the car before a crash, the sensors analyze data and sends it to the Braking Bag System. The safety system in the car commands the bags underneath the car to swell in an emergency [18]. The system will detect an imminent crash, the information will be sent to the control unit to control the airbag which is located in the vehicle floor above the front axle carrier to deploy. This action will lower a panel to the ground, to slow down the car. This decreases the aerodynamics but increases the friction of ground surface to the tire. The Braking Bag System improves wheeled braking power and assists the driver to stop the car faster in a shorter distance. [19]

Figure 8 *Braking bag system for the car [18].*

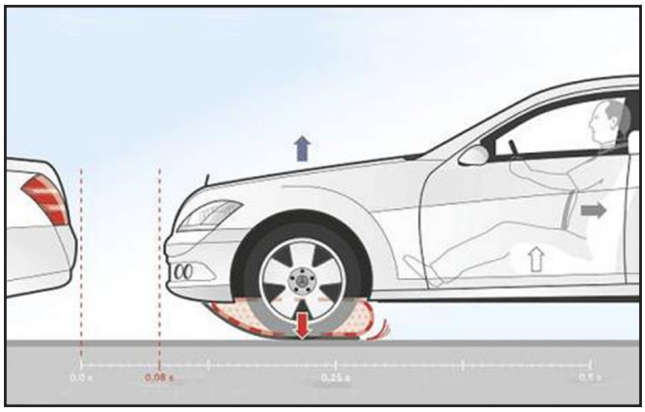

Figure 9 *External airbag slows car in a crash [19].*

2.4 Distance Assistant Controlling Systems

When driving a long way, drivers must concentrate on the road and environment. Also drivers must control the gap between vehicles in front, even though traffic and fast flowing scenarios which can be stressful. To make drivers more comfortable, the system is able to alert the driver if the gap between two cars is to close.

2.4.1 Adaptive Cruise Control System

A system was designed to help drivers maintain a safe distance between vehicles. The system uses radar sensors to measure the distance of vehicles in front and automatically controls the speed to maintain that distance continually. Volvo has developed Adaptive Cruise Control (ACC), the ACC functions are controlled by the driver's cruise control, it is able to control the speed between 30 – 200 km/hr and choose different interval times to the front car. When the speed of the front car changes, the system will adjust the speed

automatically to maintain the gap between the two cars continually [20].

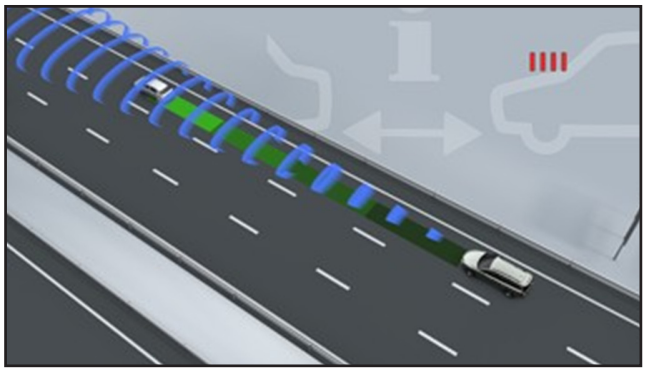

Figure 10 *Collision warning in function [20].*

2.4.2 Distance Alert System

Distance Alert System is another safety feature to help the driver maintain the gap between vehicles.

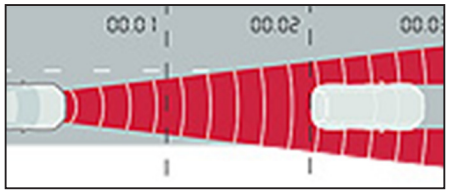

Figure 11 *ACC with distance alert [21].*

In the case that the Adaptive Cruise Control is switch off, and the gap between the users' car is close to the car in front, an alert signal will activate. This feature will inform the driver to become focused on the proper distance [21].

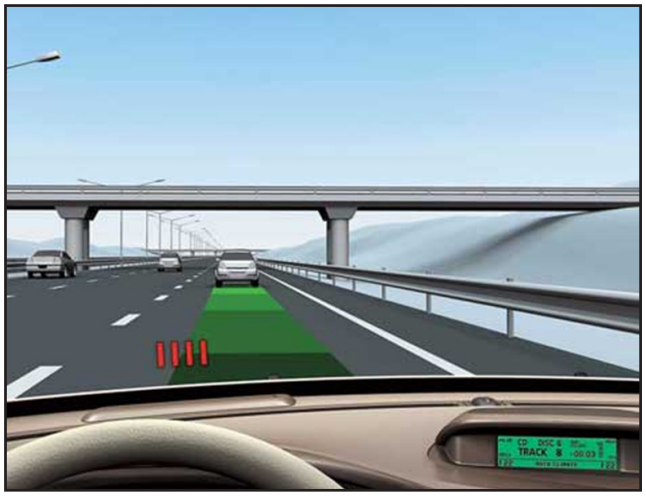

Figure 12 *Distance Alert Warning signal [22].*

2.5 Night View Vision Assistant System

One of the worst conditions when driving a car is poor visibility, especially at night time as drivers have difficulty seeing outside clearly. There are systems that can transmit a picture from outside and display it on a screen inside the car. Night vision systems were invented during World War II as a critical component of modern instruments, which allowed people to see at nighttime [23]. The concept of night view vision assistants has been developed and applied already to modern cars. Given the examples of car manufacturers who have already installed this particular system into their products, in 2002, the night view vision system was added to the Japanese Domestic Market for example Toyota and Honda [24]. Obviously, this innovation has also been introduced to luxury cars such as Lexus and Infinity as well.

Figure 13 *Night View system on the 2003 Lexus LX 470 [24].*

The system will monitor the vehicle, pedestrians and its surroundings. The highlights of those objects will be presented on an LCD display (Liquid Crystal Display) usually located in front of the driver where he or she can see it easily.

Figure 14 *The infrared night view system on Mercedes-Benz CL-Class [25].*

2.6 Beyond Intersection collisions Detection Systems

"One of the most common traffic accidents is when people make a left turn into the path of an oncoming vehicle" [26]. This was proven by statistics of surveys in 2010 which shown there were traffic collisions at 47% of all intersections [27]. To reduce this statistic, systems to detect vehicles beyond an intersection have been developed. BMW uses lasers to help prevent collisions that might occur at an intersection. The system uses information from the GPS navigation within the car and an external camera which is located in the front to scan the road ahead using lasers to detect approaching vehicles up to 328-feet away. If there is a vehicle approaching during making a turn, the system will alert the driver as it might be necessary to prepare to apply the brakes to slow down [26]. Also, Isuzu installed the front view camera to

Isuzu Super Titanium 2010. The front view camera can reduce blind spots at the front or even around the corner at intersections within a 190 degree radius [28].

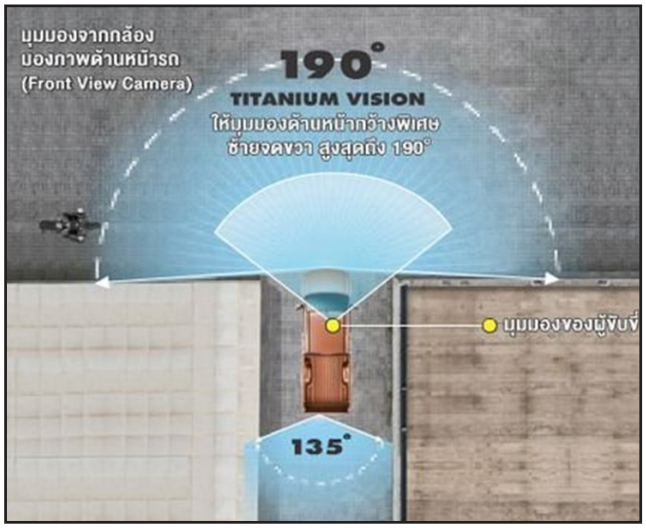

Figure 15 *Isuzu D-MAX front view camera ThaiAutoMedia.com [28].*

2.7 Tiredness Warning System

A new system to assist drivers to be aware of tiredness and drowsiness has also been developed. A study at NHTSA (The US National Highway Traffic Safety Administration) revealed that about 1.5% (100,000 cases) of all road accidents per year is caused by tiredness and drowsiness during driving [29]. Many attempts have been made to encourage people to be aware of this danger. This scenario can be avoided by having enough sleep, not driving when feeling sleepy, and taking a rest regularly to ensure you're fresh and awake. The fact is that long distance drivers do take the above advise and continue to drive when drowsy endangering everybody on the road. So perhaps this system to warn and assist them is needed. A new system from the car manufacturer Mercedes-Benz is Safety Systems for Tired Drivers. This has been developed and recently installed on most new Mercedes-Benz models [30]. The system uses various sensors to detect and analyze driving behavior and recognize tiredness, drowsiness that's associated with changes of driving style of each driver. The key indicator of tiredness can be measured from steering wheel movement behavior. Other various examples of key driver actions are not using indicators and/or poor pedal control, which altogether help grade the driving style. Also external factors influences the system such as side wind, road-surface conditions, time of day, duration of journey, and traffic situations are taken into account. Once tiredness and drowsiness have been detected, the attention assist system warns visually such as a flashing light or an emitted audible warning signal to warn the driver [30], [31]. An interesting point is that the systems should distinguish between tiredness and drowsiness or personal habits otherwise it could be annoying to the driver.

Figure 16 *How the Tired Drivers System from Mercedes works [30].*

2.8 Active Blind Spot Assist

Active Blind Spot Assist alerts the driver to the risk of collision brought about by an abrupt lane change and/or an unseen vehicle by the side (blind spot) [32].

The system can be operated from low to high speeds and can detect a vehicle in the blind spot areas even if they are at top speed. Mercedes-Benz has mentioned that their system can detect vehicles in blind spot areas at speeds between 20 and 125mph. [33]

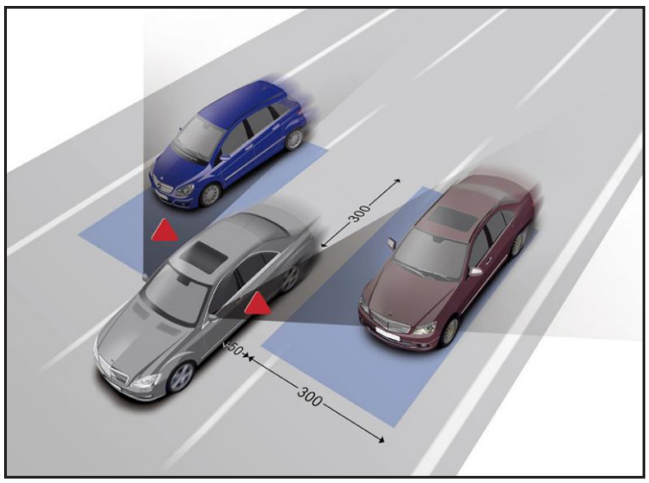

Figure 17 *Active Blind Spot Assist in action [33].*

Figure 18 *BLIS (Blind Spot Information System) in Volvo [34].*

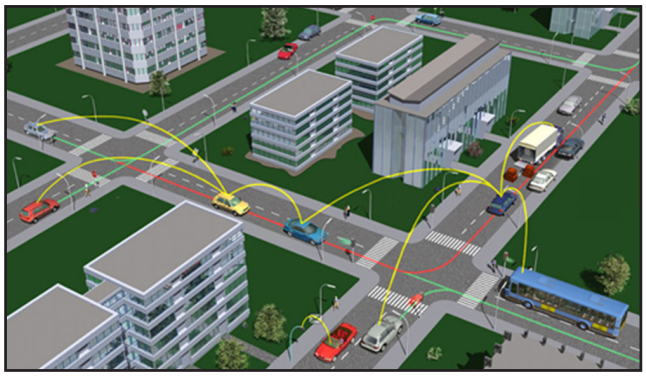

Figure 19 *Car to Car Communication System [38].*

3. Trend of Information Systems in a Modern Car

In the forthcoming years, Car to Car Communication Systems has many new possibilities, and hopefully this could significantly increase road safety. The principle concept is that cars communicate between each other on the road [35] therefore, information such as road conditions, traffic signals, volume of traffic, weather conditions, road accidents and car breakdown data will be shared and exchanged from car to car or to infrastructures nearby. Gradinescu and Iftode, et al. [36] presented an adaptive traffic light system based on a short-range wireless communication device between cars and fixed controller nodes deployed at intersections. The system controls information coming from cars and relays it to the traffic light which controls traffic flow and in turn significantly improves the performance of traffic flow at intersections. Car manufacturers are majors participants and also are the contributors that push forward car to car communication to the public. Volvo has considered this concept and described the principle of future cars as "the Speaking car". For example if two cars are about to collide head on but the drivers do not react or try to avoid the danger, the two cars communicate with each other and then counter steers by themselves [37]. Studies on Car to Car Communication by BMW, revealed by the Vice President of engineering, BMW, [38] said that progress in this particular system is going very well. The ideas of the system is that the car can alert the driver of any situation ahead and follow protocols to electronically stable the situation if need.

Mercedas-Benz has been developing a particularly interesting system based on ad-hoc networking principles and the availability of position information [39]. Today, cars and infrastructures have the ability to communicate with each other. In some countries, for example Singapore, the ERP System (Electronic Road Pricing) was implemented in 1998 to attract attention to drivers who have not paid for a parking ticket or have passed though a highway toll illegally where the ERP sensors are deployed. Also, the Singapore Government has implemented "Green" technologies to current and forthcoming systems. This approach is based on car to car communication but includes energy efficient lighting for traffic and street lights, recycled materials for road pavement construction, and construction methods that minimizes the impact on the environment [40].

Figure 20 *ERP system in Singapore [40].*

Intelligent Traffic Signs in Thailand provides real time travel information to the people who are travelling on the roads in Bangkok. Detector Camera and Occupancy Ratio (OR) techniques are used to calculate and determine the density of the ahead route. The information is shown on a screen next to or over the road, and also on the website BKKTraffic.com. However, this system does not communicate with cars on the road at the moment which is an interesting possibility for development in the future [41].

Figure 21 *Intelligent Traffic Signs in Thailand [42].*

Car to car communication systems seem to be the next big technology but at the same time a challenging one for developers. They need a wide range of information from many different sources. The management of the whole system must be carefully control. The common language used to communicate between cars or between infrastructures to cars must be advanced and reliable as many lives will depend on it daily. The communication protocols of this concept system must be taken into consideration too.

4. Summarization and Discussion of systems

To sum up, the significances or contributions of current and potential road safety Information Systems are presented in Table 1 below;

Table 1 *Summarizes the potential of road safety Information Systems and their significant/contribution.*

Information Systems	Significant/Contribution
Car Information System	Acquire important information for the journey / serviceable everywhere
Lane Keeping Assistant System	Reminder Buddy along the journey / Auto drive
Braking Assistant System	Slow down the speed before the collision / accuracy of systems
Distance Assistant Controlling System	Able to see something out of sight / quality of pictures and accuracy of systems
Beyond Intersection collisions Detection Systems	Anticipate objects out of sight / accuracy of systems
Warns Tired Drivers System	Prevent accidents from tiredness and drowsiness/ surely tiredness and drowsiness not the driver changing of habit
Active Blind Spot Assist	Reduce blind spot areas/ alert but not disturb
Car to car communication System	Anticipate the situation and decide to avoid automatically / common language and protocols of communication

5. Conclusions

This paper has described the variety of intelligent Information Systems in modern cars and also the forthcoming potential road safety ideas. Those particular systems included: information from inside and outside the vehicle, Navigation systems, Lane Keeping Assistant Systems, Braking Assistant Systems, Distance Assistant Controlling Systems, Night View Vision Assistant Systems, Beyond Intersection Collision Detection Systems, Active Blind Spot Assist, and Car to Car Communication Systems.

It can be clearly seen that, today, Information Systems play a significant role toward road safety. However, systems are only in some mass produced vehicles and not found widespread among the driving community at this time. There should be a thrust forward by the next generation of car manufacturer, researcher, Government and so on to respond to the developments, management and improvements of effective systems to support those significant systems with modern cars and fulfill their potential referring to road safety in our modern life styles. Other suggestions from this paper are; the systems should be able to communicate and share information between car to car and to relevant infrastructures. Secondly, the authority should agree on a common language between system to system and protocols. Thirdly, the developed system should be able to link to other systems or technology already in everyday use. Finally, the systems should assist in harmony when driving and not disturb one during driving. These are the major challenging issues when trying to improve the safety of tomorrow's cars.

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