CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this literature review is to give an overview of studies which has been carried out till date to mitigate the risk of distracted driving. This research is an outcome from various literature studies taken from academic journals, conferences and government studies.

2.2 TECHNOLOGY TO PREVENT DISTRACTED DRIVING

The concern of distracted driving can be tied to the research carried by Bruyas et al (2008) which found attention sharing generated by phone use appears to increase the driver’s mental workload thereby overloading the driver’s cognitive capacities and impaired the driving performance. The study carried out on cognitive distraction by Harbluk et al (2002), Strayer et al (2003) shows, during the cell phone conversation, drivers are observed to be looking at the sky much more often, not at the road, traffic, or road signs. It is commonly observed that, while the drivers are in-depth conversation, they simply ignore the other road users and even close their eyes as they are imbued in their talk. This is counterproductive to driving safely. The outcome of the research carried out by Crundall et al (2005) show, driver behaviors such as impaired gap judgment, reduced sensitivity to road conditions, poor lane maintenance, and the increase in reaction time to driving-related events can all be as a result of distracted driving. The goal of
driver identification task is to classify drivers from their driving behavior characteristics, and distraction detection identifies whether the driver is under distraction due to secondary tasks.

The work carried by James (2011) show, driver distraction is an obvious risk and it is not difficult to understand, since everywhere anyone in traffic can look at the people who are constantly in a head-down driving position as they try to dial a number, changing music on smart phone; watch those drivers engaged in conversation who cannot maintain consistent speed, drift towards the center line, or do not move when the light changes from red to green. Appropriately identifying driver distraction in real time is a critical challenge in developing these distraction mitigation systems, especially in detection of cognitive distraction which needs integration of a number of eye movement measures (e.g., blink frequency, fixation duration, and pursuit measurements) and performance measures (e.g., steering wheel movements and lane position) across a relatively long time interval but unfortunately this function was not well developed. The study carried by Liang (2009) show, differences in visual behavior and driving performance associated with different types of distraction was found by using different sets of sensors and algorithms. The algorithms for distraction detection are mostly based either on eye measures or on driver performance measures (e.g., speed, lane position, and steering).

The technique proposed by Azman et al (2010) is based on a physiological measurement to detect driver cognitive distraction. Two types of physiological measurements, eye and mouth movements are obtained using the faceLab seeing machine (it’s a technology with a focus on vision based human machine interfaces which tracks human faces and certain facial features) and their relationship to each other are analyzed using Pearson-r correlation. Their analysis proved that using a combination of eye and mouth
movements as well as other existing features may greatly improve the performance of a driver cognitive distraction detection system. The work carried by Rongben et al (2004) monitors the relationship between mouth movement and driver fatigue or distraction using a camera. Normally, the mouth is hardly open when the driver is alert. The maximum width and maximum height can indicate different levels of distraction. The height between top lip and the bottom lip varies greatly when one is talking, yawning or even thinking. In human science and psychological studies, it has been proved that mouth movement was a good indicator of a human’s state of mind. This system will warn the driver once the distraction is detected.

There were few more techniques proposed by the researchers to detect the drivers distraction based on only eyes. For example, a technique proposed by Hayhoe (2004) for detecting driver’s distraction by linking eye movements (fixation, saccade, and smooth pursuit), cognitive workload and distraction. Fixations occur when an observer’s eyes are nearly stationary. Saccades are very fast movements that occur when visual attention shifts from one location to another (i.e., When drivers try to get their phone from the pocket or observing the display of the phone to find who is calling) while, smooth pursuits occur when an observer tracks a moving object such as a passing vehicle. Further, Liang et al (2007) also uses the eye movement as their main feature to detect cognitive distraction on a driver. They used blinking, saccade, eyelid movement and pupil diameter and the characteristics of fixations, saccades and smooth pursuits to recognize the patterns of eye movements. The research proposed by Fisher et al (2009) tracks the driver’s eye using a sensor to determine whether the driver is distracted while using cell phone and a warning signs is given to the driver which effectively increase the driver attention to the roadway. Similarly, the work carried out by Miyaji et al (2009) shows, the standard deviations of eye movement and head movement could be suitable for detecting the states of cognitive distraction.
(drivers divert their attention and focus on the topic of the phone conversation). All of these techniques introduced a forward warning system that employs driver behavioral information. These systems determine driver distraction when it detects that the driver was not looking straight ahead.

There are few more studies which consider the position of head along with eye gaze to detect distraction and some studies also considers vehicle surrounding state. For example, the research carried by Pohl et al (2007) used head pose (driver will usually tilt the head towards left or right when they engage in conversation) and eye gaze information to model the visual distraction level, which was time dependent on the visual focus, with the assumption that the visual distraction level was nonlinear: Visual distraction increased with time (when the driver looked away from the road scene) but nearly instantaneously decreased (when the driver refocused on the road scene). Based on the pose/eye signals, they established their algorithm for visual distraction detection. First, they used a distraction calculation to compute the instantaneous distraction level. Then, a distraction decision maker determined whether the current distraction level represented a potentially distracted driver.

Auto companies like Toyota, Volvo, Nissan and Benz have installed driver inattention monitoring systems on their top-brand vehicles. It is reported by Yanchao et al (2011) that, Toyota developed their Driver Monitoring System in 2006 for the Lexus models. This system features a camera, which uses near-IR technology, mounted on top of the steering column cover. It monitors the exact position and angle of the driver’s head while the vehicle is in motion. If the Advanced Pre-crash Safety system detects an obstacle ahead, and at the same time, the Driver Monitoring System establishes that the driver’s head has been turned away from the road for very
long, the system automatically activates pre-crash warnings. If the situation persists, the system can briefly apply the brakes to alert the driver.

Saab’s designed a Driver Attention Warning System for the detection of distraction which consists of two miniature infrared (IR) cameras: one camera installed at the base of the driver’s A-pillar and the other camera at the center of the main fascia, which were focused on the driver’s eyes. It also utilizes the SmartEye software (Smart Eye Pro 2002) to get accurate eyelid, gaze, and head orientation information. In their algorithm, the driver’s eye blinking frequency was measured. As soon as the driver’s gaze moves away from what was defined as the “primary attention zone”—the central part of the windshield in front of the driver—a timer starts counting. If within 2 seconds of the timer being triggered the driver’s eyes and head do not return to the “straight ahead” position, it was considered a distraction. Once the driver distraction has been detected, a seat vibration signal was issued to warn the driver. However, the study carried out by Ahlström et al (2009) shows, there was no report about the robustness of this system.

The techniques proposed by Doshi and Trivedi (2009) fused head orientation detection and a saliency map of the surroundings to determine whether there was a salient object in the driver’s view, which gave an indication of whether a driver’s head turn was motivated by the goal in his/her mind or some distracting object/event in the environment. The non-contact driver monitoring systems proposed by Takemura et al (2003) analyze the facial expressions through video, as well as vehicle dynamics through on-board navigation sensors and develop a warning signals was sent to the driver prior to a potential crash.

The approach carried out by Pohl et al (2007) makes use of the driver’s face vector which in principle was the detection of direction of the driver’s nose tip, and eyeball detection to prevent the distraction. The
processes start if the vehicle departs from the lane and the driver was detected as distracted, then an intervention was triggered which sends a warning to the driver. The study carried by Itoh (2009) pointed out, that performing a cognitively distracting secondary task (e.g., talking or thinking about something) during driving would decrease the driver’s temperature at the tip of the nose, and this effect was reproducible. Similarly, it was reported by Wesley et al (2010) that a considerable and consistent skin temperature changes was measured by using physiological sensor that could be observed during cognitive and visual distractions.

The research demonstrated by Dong et al (2010) show, a real-time tracking kernel for stereo cameras to estimate face pose and face animation, including the movement of the eyelid, eyeball, eyebrow, and mouth, for driver inattention detection. The technique proposed by Smith et al (2003) was to analysis global motion and color statistics to robustly track a driver’s facial features. Using these features, they estimated continuous gaze direction. Once distraction was detected, a beep or warning message was given to the driver. However, these methods cannot always localize facial features when the driver wears eyeglasses, makes conversation, closes his eyes, or rotates his head. It also failed to work at night.

There was also distraction or inattention detection system based on the measurement of brain-waves, heart rate and pulse proposed by Saito et al (1992). The study carried out by Miyaji et al (2009) found, the average heart rate was increased by approximately 8 beats per minute when conversation happens, based on the finding, a warning or alarm will get triggered to prevent distraction. In-order to measure heart rate, pulse and brain-waves multiple sensors were attached to the driver which may causes annoyance to the driver. This may even affect the driver such that it changes the driving behavior, which was not good at all in traffic safety research. The three proto-
designs to incorporate contact sensors to enable both the driver safety and to enhance overall in-vehicle safety were proposed by Patil and Hansen (2009). The advantage of using a contact sensor was its ability to capture driver’s physiology accurately (such as heart beat and breathing patterns).

Many researchers consider the fact that even small improvements in safety may have an impact on reducing deaths in vehicle crashes and carried out a various work to determine whether the use of a speech recognition system, could control in-vehicle systems and suggested as a solution to driver distraction. The speech recognition system proposed by Itoh et al (2004) allows drivers to utter a command that is recognized by the interface to control equipments in question such as turn on a radio or to enter data such as a destination. It measures the driving performance by using speech recognition system when compare to manual and found a significant decrease in the standard deviation of lateral lane position. The study carried out by Forlines et al (2005) on a simulated driving task, by comparing speech with a manual system and found speech recognition system was more efficient and less distracting.

The studies proposed by Itoh et al (2004), Forlines et al (2005) have shown that drivers can achieve better and safer driving performance while using speech interactive systems to operate an in-vehicle system compared to manual interfaces. Although providing better interfaces, operating a speech interactive system will still divert a driver's attention away from his or her primary driving task with varying degrees of distraction. Ideally, drivers should pay primary attention to driving, rather than any secondary tasks.

It was later found out by Jannette and Mark (2009) that, both manual and speech control in secondary IVIS interaction tasks led to significant increases in reaction times and found no consistent significant difference in number of steering reversals i.e., in deviation of lane position.
Similarly, result obtained by Lee et al (2001) shows, speech controlled in-car systems leads to an increase in reaction times. The technique proposed by Gellatly and Dingus (1998) measures the task performance of a speech recognition system and found task completion time will decrease mostly between manual conditions. In some case, the results of task performance are a bit more mixed. For example, drivers can often dial a phone number more rapidly while driving using thumb dialing of a hand-held unit than speaking the phone number.

Few more limitation of speech recognition system raises the issue, for example, a study carried by Lawrence et al (2005) found, a car is particularly difficult environment for speech recognition due to environmental noise and competing vehicle sound sources. The work carried by Hansen (Hansen 1996) show, a sophisticated speech system should also be able to distinguish between speech directed to it and other auditory input. More importantly, the drivers also had to modify their vocal effort to overcome noise levels in their cars. Such effects on speech production (e.g., speech under stress) can degrade the performance of automatic speech recognition (ASR) system more than the ambient noise itself. The work carried by Brouwer et al (1991) show, the speech recognition technologies will aid older drivers in their performance of concurrent tasks while driving. The study carried out by comparing two email systems – simple speech vs. non speech is proposed by John et al (2001). This research found, speech-based interaction introduced a significant cognitive load. More guidelines should be focused on speed recognition system since as real human speech, especially for cognitively-loaded humans, is highly disfluent, full of re-starts and revisions, “uhms” and “ahs”, fragmented ungrammatical sentences, etc.,

The study based on drivers observed behaviour when performing in-vehicle common tasks such as operating a cell phone was analyzed by
Jinesh (Jinesh 2011). The study employs the UTDrive platform—a car equipped with multiple sensors, including cameras, microphones, and Controller Area Network-Bus (CAN-Bus) information. The purpose of the analysis was to identify relevant features extracted from a frontal video camera and the car CAN-Bus data that may be used to distinguish between normal and task driving conditions. Once distraction was identified, a warning or alert was given to the driver.

The study carried by Kircher et al (2009) developed a system which detect and prevents the driver distraction. Authors designed a vehicle which was instrumented with video cameras, an automatic eye tracker and GPS receivers. Further, data were read from the CAN bus of the car. The data were logged continuously with high frequency. The log system operated autonomously. During the first ten days a behavioral baseline was collected. Afterwards the warnings were activated, such that the drivers received distraction warnings in form of a vibration in the seat when the algorithm determined that they had looked away from the forward roadway too much.

The work carried by Choi et al (2007) uses UTDrive corpus which is a subset of driving data. The UTDrive corpus consists of rich multimodal driving data synchronously acquired in actual driving environment. The recording data are two video streams (driver face and front view of vehicle), audio streams from a five-channel microphone array and a close-talk microphone array, brake and gas pedal pressure sensors, following distance, CAN(Controlled Area Network)-Bus information (steering wheel angle, vehicle speed, engine speed, and brake position), and GPS information. The data analysis of long-term behavior and distracted driving was compared to the non-distracted (neutral). Gaussian Mixture Model (GMM) and Hidden Markov Models (HMM) frameworks were used to focus on driver behavior modeling and to capture the sequence of driving characteristics acquired from
the vehicle’s CAN-Bus information to detect distraction. Further, their results showed that the average vehicle speed was lower under a distracted driving, when compared to neutral driving. Also distracted driving had a wider neutralized short-term variance than non-distracted (neutral) driving. Once these types of variation were observed, it will indicate the driver through warning message.

Many researchers make use of advanced techniques to prevent distraction. For example, the approach carried by Zhang et al (2004) uses a data mining techniques to successfully detect cognitive distraction using various measures. While, the study performed by Liang et al (2007, 2007a), uses decision tree technique to estimate driver cognitive workload from eye glances, and driving performance measures using Support Vector Machines (SVMs) and Bayesian Networks (BNs) to successfully identified the presence of cognitive distraction from eye movements and driving performance but, glances were sensitive to task complexity and visual demand (Green 1999). Similarly, Chad et al (2005) developed an Advanced Driver Assistance (ADA) to prevent driver from getting distraction due to the cell phone using Bayesian Networks. They used sensors/actuators to collect context information of both driver and vehicle.

The technique developed by Yulan et al (2007) used support vector machines (SVMs), a data mining method, to develop a real-time approach for detecting cognitive distraction using driver’s eye movements and driving performance data. This approach assessed the discrete state of cognitive distraction, but did not predict the continuous level of distraction. Once distraction was detected, they use ADA system to interact with the driver. A cloud computing based decision support system (DSS) proposed by Shah and Rakib (2011) to prevent the drivers from using in-vehicle hand-held devices while driving. As a first step, it determine whether the vehicle was in
motion using odometer reading or using an onboard GPS navigation system and it captures video and audio data inside the vehicle using in-vehicle camera for the detection of driver’s carrying or interfacing with hand-held device. Once it detected, a warning message was given to driver.

Few researchers have developed a lane departure warning system in preventing distraction based on steering wheel movements which greatly deviate when using the cell phone. For example, the work carried by Farid et al (2006) tried to distinguish between attentive and inattentive driving in car-following situations by analyzing the vehicle following distance and steering angle. This system warns the inattentive driver, when considerable amount of deviation in steering angle and the vehicle following distance was noted. This study is in agreement with study carried out by Regan et al (2009) show, steering wheel movements may be considered as an indicator of secondary task load when a driver uses the cell phone. Since, the deflection area of the steering wheel was large for cellular phone use. The technique proposed by Batavia et al (1997) show, the system would triggered a warning signal when the drivers crossed the lane boundaries were detected. The problem with this technique was a warning signal would be given every time when the drivers crossed the lane, it doesn’t take into consideration that the crossing could be intentional. To overcome this difficulty, Pauline (2004) proposed a technique which suppressed this redundant warning by initially detecting whether the driver was attentive or distracted by manipulating eye movement, position of the pedals, vehicle speed and steering wheel signals. They show that it can suppress up to 70% of redundant warnings.

In 2007, Volvo Cars introduced Driver Alert Control to alert tired and non-concentrating drivers. With the idea that the technology for monitoring a driver’s eyes was not yet sufficiently mature and human behavior varies from one person to another, Volvo Cars developed the system
based on the car’s progress on the road. It was reported that Driver Alert Control monitored the car’s movements and assessed whether the vehicle was driven in a controlled or uncontrolled way. It also covered situations where the driver focused too much on his/her cell phone or children in the car, thereby not having full control of the vehicle.

The study examined by Cameron and Keith (2011) makes use of computer vision in Advanced Driver Assistance Systems, specifically for determining the level of distraction that the driver is suffering from. ADAS utilizes computer vision as well as lane detection in order to obtain physical information about the driver and the accuracy of their driving. First, the computer tracks the face of the driver using an AdaBoost algorithm and light compensation methods. The driver assist system then collects data through methods of measurement such as percentage of eyelid closure (PERCLOS), gaze direction, and yawn frequency, for later computations. The computer condenses the gathered information into a single quantitative variable using fuzzy integration. Based upon the data the system is able to analyze, it can identify when driving errors transpire or when they are more likely to occur. After producing the driver index the computer decides whether to alert the driver if they are overly fatigued, or step in to compensate for unintended activity.

A vehicle test-bed proposed by McCall et al (2004) capture not just a portion of the vehicle but rather the entire vehicle surround as well as the vehicle interior and vehicle state for extended periods of time. This is accomplished using multiple modalities of sensor systems and cameras so that it can form a complete context of the vehicle. An intelligent vehicle test bed created to accomplish the tasks of 1) collecting data on driver behavior in order to respond various situations and better understand the drivers intent, 2) testing algorithms for sensing the vehicle context, including its interior, and
feeding that back into the vehicle’s user interface and 3) collecting complete
surround data (both interior and exterior) in order to create an annotated
ground truth data set for training of intelligent systems. If the driver is getting
distracted i.e., by talking on a cell phone, the vehicle will warn the driver
earlier of an impending critical event.

There were few studies carried out by the researcher to prevent
distracted driving due to cell phone by providing traffic or driver state to the
caller. For example the study carried by Mike and Sara (2005) explores the
possibility of reducing distraction by providing callers with remote
information about the driver’s traffic. Similarly, the work carried by Huang
and Trivedi (2003) towards the development of novel driver assistance
system, “Visual Capture, Analysis and Televiewing (VCAT)” which
provide an example of a context-aware system, as one that attempts to alleviate driver
distraction caused when using a mobile phone, by providing contextual
information to the remote caller. This enables the remote party to observe the
driving context while the conversation is taking place, as though they were a
passenger in the car. This technology is envisaged to give the electronic
“passenger” the same access to visual cues, allowing them the ability to alter
the conversation style, as though they were witnessing the same thing as a
passenger.

A novel sensory system along with the interfaces was proposed by
McCall et al (2003) to enhance the safety of a driver who might be using a
cell phone. This work is based on the premise that, a safer mode of
communication between a remote caller and the driver could be achieved by
providing the remote caller with visual feedback of the drivers affective state
as well as an indication of the driving conditions in real-time. The system
was developed for real time affect analysis and Tele-viewing in order to bring
the context of the driver to remote users. The system was divided into two
modules. The face recognition module recognizes six emotional states of the driver. The face-modeling module generated a 3D model of the driver’s face using two images and synthesized the emotions on it. Depending on bandwidth, either a raw video, 3D warped model, or an iconic representation was sent to the remote user.

CarCoach, an educational car system proposed by Sharon et al (2005) was based on generalized layered architecture. It used different sensors and inducers like temperature, humidity, pressure, stress, car gear state, GPS and many more attached inside the vehicle. Based on the sensors, stress was measured on a driving activity such as driving in reverses or performing maneuvers such as changing lanes, turning etc., Application was meant to suppress the cellular phone rings as long as when the driver under stress was detected. The stress was measured based on the behavior of drivers which might be potentially detected by using pressure sensors on the steering wheel, with the assumption that the amount of pressure applied on the steering wheel often increased when the driver was in stress.

The study carried out by Michon (1993) was based on the driver’s workload. It permitted the drivers to do a wide range of tasks when the driving workload was low, but provided constraints when the workload was high. This flexibility was achieved by a workload manager, software and hardware that would assess the driving demands and driver capabilities on a moment-to-moment basis, and regulated the flow of information to the driver accordingly. For example, incoming cell phone calls might be automatically routed to an answering machine in heavy traffic, but permitted when no traffic was present on a straight road.

The possibility of identifying typical driver’s activities inside the car by evaluating pressure patterns was found by Riener and Ferscha (2007). The patterns collected from force sensor arrays are integrated into the fabric
of the driver seat and backrest. They have also developed an algorithm for sitting posture recognition, and empirical studies are performed to assess the reliability of activity recognition from the sitting postures. By using sensors located in a backrest of the driver, use of cell phone by the driver can be identified since there will be raise in pressure of one shoulder additional they used a camera to capture arm for confirmation. Once both the condition met, a warning or alarm will be given to the driver to prevent distraction.

The study carried by Healey (2005) collects and analyzes physiological data such as electrocardiogram (ECG), electromyogram (EMG), skin conductance and respiration during real world driving tasks to determine a driver’s relative stress level. During high stress situations incoming cell phone calls was diverted to voice mail and navigation systems were programmed to present the driver with only the most critical information. The study based on electroencephalography (EEG) signal which contain information about the task engagement level and mental workload was proposed by Berka et al (2007). Once a cognitive or visual distraction found, an alert was activated to the driver. While, the outcome of the research carried by (Bouchner 2006) shows, EEG was extremely dynamic and sensitive to outside factors. In addition, EEG patterns vary between individuals.

The research carried by Amardeep et al (2008) proposed an initial analysis of a system for detecting driver distraction using data from the Controller Area Network (CAN) and motion sensor (accelerometer and gyroscope). This research mainly focuses on distractions perceivable with leg and head movements of the driver. A sensor on the leg will indicate transitions between the accelerator and brake. A sensor on the head will indicate the movement of the head from left to right or a tilt to answer a phone call. The leg and the head movements are measured using a tri-axial accelerometer and bi-axial gyroscope mounted on the sensor node. Once
variation in speed and movement of the head is detected a warning or corrective mechanisms was used to reduce the intensity of accidents which may cause due to driver distractions.

The work carried by Chieh-Chih et al (2012) proposed a system which located the cars on the road on which drivers were distracted, and it provided a warning message to the driver along with it also displayed message (e.g., Distracted !) to the surrounding cars through IVI system that would be visualized on top of their associated vehicles. They implemented system using FaceAPI and an RGB-D camera that could track face and hand postures. The system models and tracks the users face and determines whether or not the driver is looked forward. They model this attentive gaze with a rectangular boundary. When the driver’s gaze was within the rectangle, no warning was produced, but when the driver was not looking at the road, the gaze would be shown outside of the rectangular region, and the —Distracted warning was produced.

A system proposed by Marie (2010) on detecting motion of a cell phone and disabling the use of the cell phone while moving or driving. The system included: a cell phone, a sensor to detect motion of the cell phone, software in the cell phone to disable the use of the cell phone when motion was detected.

There are many active efforts taken by the researcher to prevent the driver from getting distracted due to in-vehicle technology like cell phone, however, very limited research is identified wherein methods to differentiate whether the cell phone used in vehicle is either a driver or the passenger. For example, the study carried by Hon et al (2011) presents a phone based sensing system, referred to as driver detection system (DDS), to determine if a user in a moving vehicle is a driver or a passenger by using various user micro-movements that can be detected using the mobile phone sensors
(accelerometer, gyroscope, compass and microphone) which are capable of capturing and inferring significant amounts of information about the user’s status and activities. This detection is based on inferring which part of the vehicle the user is present in, such as passenger side vs. driver side or front vs. rear, the directions in which the driver and a right side passenger reach for a seatbelt and wears it are different, as well as some key activities performed by the driver. Further, the system helps the mobile device’s to identify the user’s available attention and focus, enabling it to control delivery of potentially interrupting events such as incoming calls and messages.

The research carried by Jie et al (2011) developed a cell phone detection scheme using an acoustic approach wherein a phone leverages the built-in Bluetooth and a car stereo to generate a series of high frequency beeps over the stereo. The phone records these beeps, which are spaced in time across the left, right, and if available, front and rear speakers, and times their arrival. Using a differential range approach to estimate the phone’s distance from the car's center, a passenger or driver classification is made. Further, Shabeer and Wahida Banu (2009) proposed a system which measures speed of the vehicle using digital speedometer and transmits the speed to the application installed in the driver’s cell phone and change the profile of the cell phone from loud to silent once the speed exceeds a predefined speed.

Apart from these efforts, there have been some contributions which help in reducing the level of driver distraction while using their cell phone by allowing methods to promote ease of handling and interaction. The technique proposed by Janne and Jason (2011) reduces the need to operate a mobile phone while driving by using context-awareness such as by notifying the location and movement of the call recipient to the caller. While, Kevin et al (2008) present BlindSight which is a prototype application having the ability to replace the traditionally visual in-call menu of a mobile phone. Users
interact using the phone keypad, without looking at the screen i.e., users with access to personal information stored on their mobile phone while talking on the phone. BlindSight responds with auditory feedback. This feedback is heard only by the user, not by the person on the other end of the line.

2.2.1 Limitation

From the above studies it is abundantly clear that, during last few years many researchers have been working on systems for driver inattention detection using various techniques. Even though the most accurate techniques proposed by Patil and Hansen (2009), Jennifer (2005), Berka et al (2007) are based on physiological measures like brain waves, heart rate, pulse rate, respiration, etc., These techniques are intrusive, since they need to attach some electrodes on the drivers, causing annoyance to them.

A driver’s state of vigilance characterized by indirect vehicle behaviors like lateral position, steering wheel movements, and time to line crossing was carried out by Farid et al (2006), Akira et al (2008), Regan et al (2009). Even these techniques are not intrusive because they are subject to several limitations such as vehicle type, driver experience, geometric characteristics, state of the road, etc. On the other hand, these procedures require a considerable amount of time to analyze the user behaviors and thereby they do not work in real time.

The technique proposed by Liang et al (2007) calculates 3D poses of the head and the eye-gaze direction using FaceLAB. The FaceLAB monitors the eyelids, eye opening and blink rates. With this information, the system estimates the driver’s fatigue level. According to FaceLab information, the system operates day and night, but at night, the performance of the system decreases. This system relies on manual initialization of feature points.
There are other proposals that use only a camera. For example, the technique proposed by Boverie et al (1998) found a 2D pupil monocular tracking system based on the differences in color and reflectivity between the pupil and iris. While, the study based on head/eye monitoring carried by Smith et al (2003) uses a single camera, which is based on color predicates. Both these systems are based on passive vision techniques and its functioning can be problematical in poor or extremely bright lighting conditions.

The real success of the algorithms proposed by Kircher et al (2006) for distraction detection system design is in the ability to predict the state of distraction based on driver perception and control metrics. Similarly, Liang et al (2009) proposed distraction detection algorithm need to be customized for different drivers, which makes it more difficult to implement.

The system relying on a single visual cue proposed by Jie et al (2002) encountered difficulties when the required visual features cannot be acquired accurately or reliably, as happens in real conditions. Furthermore, a single visual cue may not always be indicative of the overall mental condition. Though, the use of multiple visual cues proposed by Kircher et al (2006) reduces the uncertainty and the ambiguity present in the information from a single source. However, the multiple visual systems must be personalized for each driver during a learning phase.

Apart from these, there are few more serious things that should be focused on, since many of the researches claimed very high detection accuracies, which were true only for their particular hypothetical fatigue/distraction definitions. These hypothetical definitions usually covered a limited region of the whole fatigue/distraction definition. Without this condition, the accuracy rates had no meaning. Because of the significant difficulties inherent in measuring driver attention, the magnitude and, particularly, the safety
implications of driver distraction have been very difficult to determine. The work described by Donmez et al. (2006) showed, the issue associated with the accuracy of distraction detection is because of high number of false alarms (false adaptation) which could lead the system to mistrust. Another issue is that, the driver’s limited capacity can make it difficult to perceive all the incoming information and understand the reasons for the real-time feedback while driving.

Context-aware system developed by Huang and Trivedi (2003), Janne and Jason (2011) gave more information to humans and not to devices, and did not attempt to reduce driver distraction by removing simultaneous information conflicts. Further, the research carried out by Hon et al. (2011) to differentiate between the driver and passenger also had its limitation. This DDS system was based on many assumptions, for example, it assumed that all passengers in the car would wear a seat belt and the system would fail if the phone was in the handbag or when the rear passenger entered the car from the driver side.

The system proposed by Jie et al. (2011) failed, when the driver places the phone on an empty passenger seat or when the phone was muffled by the bag or coat. One more obvious objection to this approach was that not all cars have Bluetooth yet. While, the system proposed by Shabeer and Wahida Banu (2009) might miss an emergency call for the driver, since the application would automatically change the profile of mobile phone into silent mode while driving, and the application installed in the mobile phone should always run on the background which would drain the battery or the driver had to start the application manually which was not always possible since most of the time they might forget.
2.3 MOBILE APPLICATIONS TO PREVENT DRIVER DISTRACTION

Mobile application development is the process by which application software is developed for small low-power handheld devices such as personal digital assistants, enterprise digital assistants or mobile phones. These applications are either pre-installed on phones during manufacture, downloaded by customers from various mobile software distribution platforms such as android market.

There are few mobile phone applications developed and available to reduce the dangers of distracted driving and particularly to prevent cell phone use while driving. Most of these devices and application have been created and marketed in the past 2 or 3 years. There are many companies which develop mobile applications and try to make it possible for the drivers to enjoy connectivity safely and easily with “Eyes on the Road and Hands on the Wheel” to eliminate driver distraction due to the use of a cell phone. Typically the solution comes in two categories:

Cell Phone Application

It determines whether a cell phone is in a moving vehicle or not, based on cell phone handoffs, cell phone signal strength, speedometer or by using Global Positioning System and based on above speeding techniques application will disable most or all of your phone's functionality once a pre-determined speed is reached.

Combination of Hardware and Application

Instead of relying on GPS or other speeding techniques to sense car usage, a small module gets attached to a part of a car such as the emergency
brake or the OBD (on-board diagnostics) module. Once the module is triggered by car usage, a signal disables the phone or performs other actions as instructed in application.

The reviews on various cell phone distraction applications were carried out by Linda and Helen (2011). PhonEnforcer is a mobile application which works on GPS enabled mobile phone which will automatically turn off the cell phone, when the user in driving is detected, and it also sends notifications to safety managers that assure the application is working and that detects any attempt to disable. Sprint and iZup developed an application which disables the phone functionality when the car moving is detected using internal GPS or by cell tower triangulation or are linked to a vehicle through an external GPS receiver and transfers all incoming call to voice mail. While, Phoneguard application will lock the phone’s keypad when the phone (vehicle) is moving faster than 10 mph (Miles per Hour) as detected by GPS and it allows the user to make only 911 calls. In addition to this feature it allows the administrator to set a speed limit on the phone, for example, if the speed limit is set at 65 mph and the phone is traveling faster than the specified speed, a text message will be sent to the admin with a Google map showing the location of the automobile and the speed at which it is traveling. ZoomSafer is another application that suppresses call and text messages and sends custom auto replies explaining that the cell phone owner cannot receive calls or texts because he or she is driving.

DriveSmart application automatically detects when the cars in motion using GPS and all the incoming call will be automatically sent to voicemail, and incoming text messages are met with an automatic response that the recipient is currently driving. Naturally, there's an emergency override built-in – in case the user is not the driver he/she can override the application as passenger where phone works in normal mode but to make sure young
drivers are not abusing it, DriveSmart offers parents the option of being contacted by text or email when it is overridden and can let them monitor overall phone usage through a web interface.

The review on cell phone applications has been carried by Benden et al (2012). The device Key2SafeDriving system has been developed by Safe Driving Systems LLC. This system involves downloading software to the driver’s phone and installing a transponder into the onboard diagnostics version II (OBD II) port in the driver’s vehicle. This transponder communicates wirelessly with the phone when the vehicle is started. The software then places the phone in “safe mode,” which blocks all incoming phone calls and text messages except for the three emergency numbers encoded into the software when it is installed. Inbound and outbound calls can be made to the emergency numbers when the vehicle is in operation. The phone will revert to normal operation when the vehicle is shut off. The transponder and software are tamper proof in that the administrator (parent) will receive a text message when the device is initially operational, and any time the transponder is removed or altered.

Cellcontrol developed an anti-distracted driving system which consists of Cellcontrol application along with hardware and uses GPS of the cell phone or Bluetooth in the vehicle to determine whether the vehicle is moving, and a hardware device which must be connected to the onboard diagnostics port or to the vehicle's electronics system. Once vehicle in motion is detected, an application will forward the incoming calls to voice mail and it locks the keys of the phone to prevent driver from dialing or texting while driving.

WalkSafe, an application has been developed to improve the safety of pedestrian mobile phone users. The application uses the back camera of the
mobile phone to detect vehicles approaching the user, alerting the user of a potentially unsafe situation.

2.3.1 Limitation

No application is able to differentiate whether the cell phone user is either with the driver or passenger. If you are a passenger in a vehicle, you have to override the application as passenger else, an application disables your phone as well. There was a high chance that the driver can misuse this function. One more issue with these applications is, it fails to deal with an emergency call option. Till date no application has been developed so far to provide with an option to attend a real emergency call. Since, some of these applications developed would send the call directly to voicemail while driving. In addition to this, almost all the applications discussed rely on either GPS or Bluetooth which in turn may drain the phone battery soon.

2.4 SUMMARY

From the literature studies, it is evident that various techniques or systems have been developed to detect and prevent the driver’s distraction and very few techniques been introduced to detect the location of cell phone either near the driver or passenger seat. This chapter also discussed the research gap that exists in the technologies or systems developed, for example, no single system has been developed to identify whether the cell phone user inside the vehicle is either the driver or the passenger and similarly, no mobile application been developed so far which tells the caller about the elapsed time of the driver to reach the destination and no application available, which provides provision to attend an emergency call when driver stops the vehicle.