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An Integrated Safety Warning System For Driver Fatigue Awareness

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Abstract: *The safety is very critical in the automotive industry and it would be a vigorous proposition to have an innovative safety feature that would prevent the driver from falling asleep while driving. With the aid of today's technology, photographic equipment can be used to recognize when the driver's eye lid proceeds to mantle and Sclera/Pupil are no longer defined. The TTL serial camera module with NTSC video output will use the Arduino 101 with an Intel Curie microcontroller to send a signal to the driver seat. An unbalanced impeller could be utilized to receive the output data signal emerging from the microcontroller, which is wired to the data input of the impeller. The signal input will activate the impeller to vibrate the seat. Therefore, the driver is alert of the situation. This process can continue to be implemented until the eyes are recognized as opened again. This innovation will be essential when concerned about safety and will decrease the rate of accidents due to the lack of contemplation.*

Keywords : *Driver fatigue detection, Driving safety, Automotive, Photographic, Eye tracking.*

I. Introduction

One of the most important and challenging aspects on the new highly technical designed intelligent vehicles are the accident prevention safety feature stability it provides for consumers. Accidents that occur due to sleepiness, drowsiness or fatigue out on the road are a large statistical number of overall lack of attention crashes. The safety is very critical in the automotive industry and it would be a vigorous proposition to have an innovative safety feature that would prevent the driver from falling asleep while driving. With the aid of today's technology, photographic equipment can be used to recognize when the driver's eye lid proceeds to mantle and Sclera/Pupil are no longer defined. Certain accidents can be prevented by adding a system that can detect if the vehicle's operator is transitioning into fatigue mode. There have been numerous recent studies that estimated nearly 1,200 deaths and 76,000 injuries annually are a result of fatigue affiliated crashes [1, 2].

The American National Highway Traffic Safety Administration (NHTSA) released a report that indicated that the greatest dominant factor that contributed in fatal accidents resulting from vehicles running off the road is certainly the vehicle driver's lack of attention [3]. These statistics show the importance or the need of constructing this safety feature. In a release by national sleep foundation about drivers surveyed for inclining their head, the number reached 28% for U.S. drivers that admitted to lowering and raising their head at the wheel while driving at least once [4]. These collisions take place due to driver not being able to provide their full attention to the driving task, resulting in lack of performance when operating the vehicle. In this research, an innovation will be essential when concerned about safety and will decrease the rate of accidents due to the lack of contemplation. A TTL serial camera module with NTSC video output will be used to detect the when the driver is falling asleep. An Arduino microcontroller will be used to receive the signal from the camera and forward it to the vehicle seat to be able to allow it to vibrate when closed eyelids are detected. The rest of this paper is organized as follows: Section II discusses the related work; Section III provides a detailed theory and cause of fatigue drivers; Section IV presents the photographic modules comparisons; Section V discusses the system methodology followed by system integration in section VI. Finally, we provide conclusions in Section VII.

II. Related work

Various studies have been taken place to recognize Fatigue, sleepiness and/or drowsiness and provide ways to alarm the driver when falling asleep. For the past decade, a substantial amount of fieldwork experiments have approached this automotive safety factor in a number of ways. A different approach was proposed by Singh *et al.* [5] include a non-intrusive technique that utilizes the system to detect the fatigue of the driver and uses the eye and face tracking method while driving with a vibrating seat belt to alert the driver in the case of going off-road as a result of fatigue, drowsiness or sleepiness. Son *et al.* [6] projected a method to advance this safety matter and considered it to be an influential constituent in enhancing driving safety, such method is a real-time detection for lane departure which can work very well in many weather conditions and will even work at night to provide safe driving at all time while including a warning system. Victor [7] of Volvo Technology Corporation examined such feature that understands that a driver's workload becomes much greater when using

these new intelligent functionalities and technologies, it constructed a procedure similar to previous approaches which also include monitoring of driver's head movement, eye-closure amount and driver's facial temperature. These are similar comparative ways of handling this safety situation, but this paper includes a more rigid solution for fatigue drivers and the assurance of a system that will alert the driver to be able to get their attention back on the road. Using the proposition of vibrating the driver seat is a system that has not been proposed by other studies. Chang *et al.* [8] proposed intellectual systems to deal with task such as a smartphone-based driver assistance system. This system uses the smartphone's front camera to detect if the driver is starting to be drowsy or is still conscious and the rear phone's camera will actually detect the vehicle in front of the driver's vehicle to be able to alert the operator if they get too close to the vehicle in front of them. Vural *et al.* [9] suggested a unique, yet complex approach to solve the fatigue driver issue that has been proposed. It is a machine utilized to determine authentic human behavior when going into drowsiness stages, it takes a sample of 30 facial actions using a coding system that is designed to recognize facial action. What makes this innovation unique and complex is that it looks at multiple other facial movements other than eye, head movement or yawning.

III. Theory And Cause Of Fatigue Drivers

It was until about the 1950's were the automotive industry took off rapidly and vehicles became more affordable. Making vehicle more affordable means there are more vehicles out on the road and that leads to more safety variables being taken into account. One of the most obscure safety feature that was quite dangerous and surprising was the driver transitioning into fatigue mode. Numerous types of studies have been practiced to provide and prove that tiredness, drowsiness or sleepiness while behind the wheel will eventually lead to serious accidents if the driver continues to operate the vehicle without the aid of an alarm system. Many of these accidents occur with semi-truck drivers due to the fact of being long hours on the road as their primary job is transportation. The following table shows the number of accidents that occurred in the agglomeration, as well as several measurements [10].

Table 1: Sample Size for TL and LTL Data Analysis

Truckload	**Crash**	**Non-Crash**	**Total**
Firm 1 (2004-05)	79	175	254
Firm 1 (2010)	130	263	393
Firm 2 (2010)	109	122	231
Subtotal	318	560	878
Less-than-Truckload	**Crash**	**Non-Crash**	**Total**
Firm 3 (2004-05)	45	90	135
Firm 4 92004-05)	79	188	267
Firm 5 (2010)	100	184	284
Subtotal	224	462	686
Total	**542**	**1,022**	**1,564**

Different studies have shown that driving while drowsy or fatigue will result in vehicle swerving in and out of its lane due to the lack of the operator's performance.

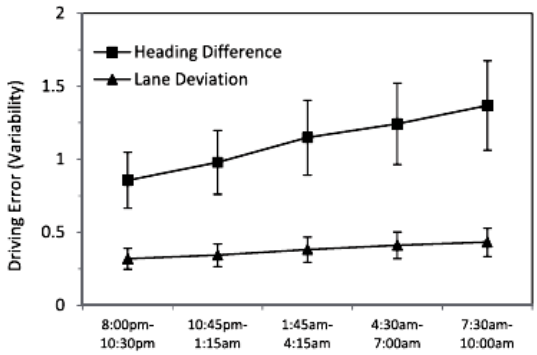

Figure 1: Driving variability using a formula for lane deviation and heading difference [11]

IV. Photographic Modules Comparison

To implement this safety feature, a camera will be required to do an analysis to the driver. There are numerus types of camera's that will work, but since this is going toward an intelligent vehicle, being cost effective must be taken into consideration. A number of cameras have been favored due to lower prices. Although cheaper camera has been recommended, the quality has not been neglected. Reviews for the cameras have been collected to provide better choice.

3.1 TTL Serial Camera

An integrated camera is taken into consideration. This type of camera module with NTSC video output is widely used with the Arduino or other similar microcontroller. This handy photographic device comes imbedded with the correct pins that can be applied on multiple applications. It can stream non-stop video along with an option that can command the video to freeze (i.e. save image) and download as a JPEG. This can occur when a motion is detected. This module can provide a maximum image of 640x480 pixels, which is relatively reasonable for what it used for. It has a CMOS ¼ inch image sensor with 0.3M pixel. It can have a monitoring distance between ten and fifteen meters and can be used for outdoors or indoors [12]. Figure 2 shows the TTL serial camera.

Figure 2: TTL Serial Camera

3.2 Microsoft LifeCam VX-5000

This webcam made by Microsoft can also be an option. It's a USB photographic device that can be used for many applications. This device was selected because it's inexpensive and reliable. It has been utilized for numerous projects towards eye recognition applications [13]. This is a fairly small yet light weight device, therefore it can be placed in front of the driver without blocking the operator's complete view. Microsoft has built this device with an extra piece of clip that allows it to be placed just about anywhere. An example would be that it can be placed on baseball cap or in the case of this implementation it can be placed on the driver's sun visors. Figure 3 shows the Microsoft LifeCam VX-5000.

Figure 3: Microsoft LifeCam VX-5000

3.3 Logitech QuickCam Pro 4000

Another reliable camera that was used for a number of projects is Logitech QuickCam pro 4000. It has been proven that this type of camera is able to carry out such experiment. This type of camera might be a good choice. It works with the aid of GazeTracker software to utilize the Haar-FaceDetector. The camera would be required to be trained using a large number of sample eye images [14]. The photographic component that will be used for this innovation will have to depend on the type of microcontroller selected for this safety feature. Figure 4 shows the Logitech QuickCam Pro 4000.

Figure 4: Logitech QuickCam Pro 4000

V. Methodology

The proposed methodology is based on eye recognition for the driver fatigue detection for the effective vehicle control system. This system detects the driver fatigue state based on eye tracking which comes under an active safety system. A number of microcontrollers could be utilized here, but only a few could be a selective

candidate due to the fact that the photographic choices have been narrowed down to only three types. An interesting type of microcontroller that may be a good candidate is the Intel curie module. Other microcontrollers like Texas instrument's 32-bit Microcontroller-MCU piccolo Micro and their ARM Microcontrollers-MCU concerto MCU are also good candidates that would accommodate with this application.

The type of microcontroller that will be used for this application is the Intel curie module. This is a very small micro controller that was introduced by Intel as the smallest module yet, as part of the low-powered processors. It was first introduced at the 2015 international consumer electronics show. The Intel curie is known to be the size of a button and it is based on the 32-bit Intel Quark SE system on chip [15]. As for this application it will be embedded in an Arduino 101 which is a recently developed module of the Arduino family with lots of new add-ons technology. The Arduino 101 is shown in the Figure below.

Figure 5: Two types of Arduino (USA on left, Outside USA on right) with Intel curie microcontroller

This unique safety feature utilizes components that will require three hardware components. These three hardware components are the photographic camera, microcontroller and an unbalanced impeller. The microcontroller that is more candidate for this implementation is unique because it uses an Intel curie microcontroller to bridge the communication between the photographic device and the vibrating seat. This unique microcontroller is soldered onto Arduino's latest mini board call the Arduino 101.

The micro controller can be used separately for cost effective or it can be used along with the Arduino 101 to allow other features to be added such as advancing this monitoring system by adding more alert variables. In the automotive industry being cost effective and finding ways to save on money and weight is very critical, therefore the components required must be efficient in terms of cost and mass. All three photographic are suitable for the task at hand. It is important to recognize the variables that distinguish this approach from other previous approaches. What makes this procedure unique is that it utilizes the driver seat as part of the integrated system. It employs the seat to vibrate as an alert or awareness for the driver. The diagram below illustrates when the seat will be used.

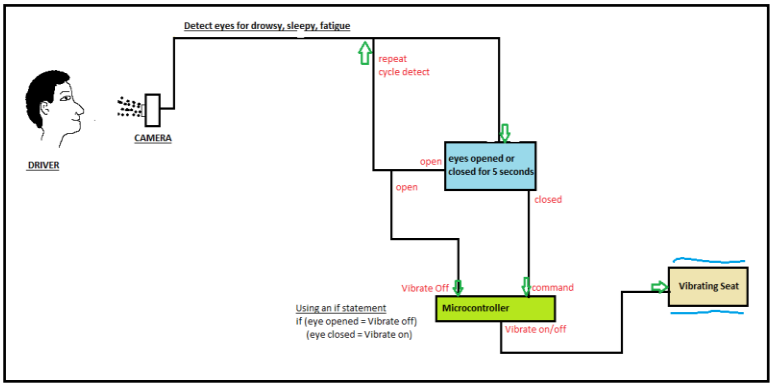

Figure 6: Construction of implementation

VI. Integrated System

This type of system is integrated into the vehicle. The schematic is shown in Figure 6. It shows how the whole safety system will be mapped out. It is required for the driver to have a clear view through the vehicle's windshield, therefore the photographic device must be places at a designated location away from blocking the driver's view while being able to capture the driver's eyes simultaneously. The video capturing device is attached to the sun visor across from the driver or on the windshield itself but away from the driver's designated view. In this case the driver is not required to search for better view when operating the vehicle.

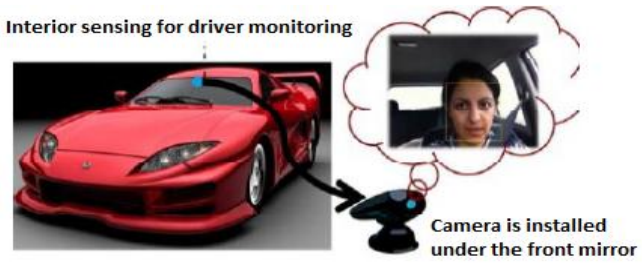

Figure 7: An example of option for photographic device location.

The photographic device will be utilized to capture real time video whenever the vehicle is in operating mode. Software is used for the analysis of the image signals captured by the photographic device. An algorithmic analysis will take place to identify if the driver's eyes are opened or closed and proceed to the next step. If the driver's eye lids do not proceed to mantle then the system will cycles again while implementing the analysis. This procedure will continue to occur until camera recognizes that the Sclera/Pupil is no longer defined in the image. The analysis will transition into the next step, which is to trigger the clock to count up to five seconds. If the real time image remains uninterrupted for time greater than or equal to five second, the analysis software will make an executive design to send a signal to the micro controller.

In this case the Arduino is utilized. It contributes by routing the signal into the microcontroller. The microcontroller decides what pin will the signal be outputted based on the designated instructed pin. The signal being sent out of the microcontroller is design to trigger the seat to vibrate using a vibration motor. The vibration motor can cause this type of disturbance by rotating with an unbalanced shaft. Figure 8 shows an example location of the image capturing device. Vibrator can come in different types of shapes and sizes. This particular type of vibration causing system is a cylinder shape that is also known as the bar-type vibration motor. It rotates at high rate of speed which causes it to lose its displacement in a periodic form which results in what is called vibration [16].

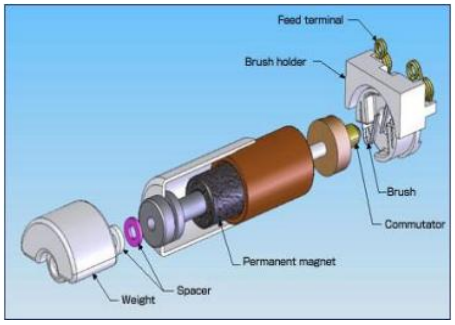

Figure 8: DC vibration motor construction

The seat will continue to vibrate in such a frequency that will cause the driver to retain their full attention to operating the vehicle. The way this is designed is that the entire procedure will continue to repeat itself simultaneously until the microcontroller receives a signal that the driver's eye lid is no longer in the closed position. This system is integrated and designed to provide rapid response to be able to accommodate a fatigue driver. Although pressure sensor for gripping the steering wheel will not be utilized in this procedure and speed variation will not be determined, there are other studies that show the danger of driving while being fatigue and unaware of the surroundings. Below are two figures that show the constant instability to stability of a fatigue driver.

In the first graph labeled steering wheel gripping pressure vs. time, it traces how the driver react when they are getting drowsy or fatigue in terms of handling the steering wheel of the vehicle they are operating. Starting from the left it shows that the driver is applying the average amount of pressure when holding the steering wheel. The drivers then tend to become weak when transitioning into fatigue mode resulting in the loss of pressure grip on the steering wheel. This could escalate if the driver continues to be fatigue and separate themselves from the wheel leading to risking getting into an accident. The second graph below plots speed vs. time which reflects the first graph. As the driver becomes more fatigue, sleepy or drowsy the vehicle's speed changes. It is shown below that the driver tends lose track of what speed they are going or what speed they are supposed to be driving when going into such a physical and mental mode like being fatigue or sleepy. The speed will then continue to oscillate because the driver is constantly losing track and then attempting to get back on track then losing track again and so on. In many cases that are not a safe way to drive because that will confuse other driver that is sharing the same road.

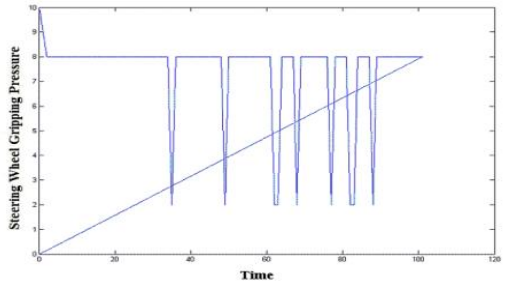

Figure 9: Steering wheel gripping pressure

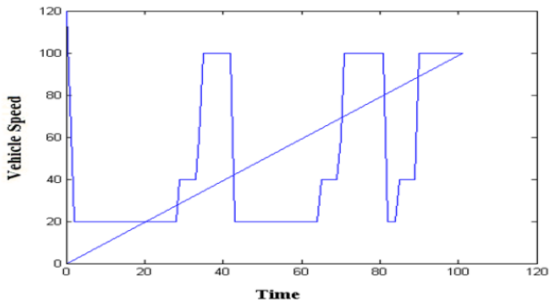

Figure 10: Vehicle speed variation

VII. Conclusion

The purpose of this safety feature is to provide a safe and accident-free process for drivers who are usually fatigue, drowsiness and sleepy while driving. This new innovative seat vibration system can better the driving stability of when a vehicles operator tends to transition into fatigue mode. The anticipated result here are straight forward, a tired driver's capability of maintaining an outstanding rigid driving attention on the road results of comfort disturbance of when attempting to fall asleep. As long as the seat does that the driver will continue keep their attention on the road. This is a system that is designed to work with any weather conditions. The reason for that is the fact the entire integrated system will remain inside the vehicle. Therefore, there will be no barrier between the driver and the designed awareness system. There would be no variable that will come between the driver and photographic device that may harm or interrupt image capturing process. This would also be suitable for night driving as that's where the majority of sleepiness occurs. Numerous studies have shown that having such warning system would decrease the results being involved in a fatigue related crash, therefore the use of advanced method of vibrating a seat as way of alerting the driver of the situation will also have a significant impact on decreasing the numbers of accidents resulting from fatigue operators.

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