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Automatic Steering Mechanism Design Using Brain Networks with Hardware Implementation

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Abstract: *This paper deals with the design and implementation of a car sitter mechanism for a driver for efficient driving.*
Keywords- *Car Driving, Steering, Hardware*

I. Introduction

This paper deals with the design and implementation of a car sitter mechanism for a driver for efficient driving. This paper deals with the design and implementation of a car sitter mechanism for a driver for efficient driving. The paper is organized as follows. Section 1 deals with a brief introduction to the paper. Section 2 deals with the electroencephalogram, driver steering methods and the eye detection techniques for efficient driving. The implementation of the hardware is discussed in section 3 followed by the outcome in section 4. The paper concludes with the conclusions in section 5 with the appendix.

In 1996, the National Highway Traffic Safety Administration (NHTSA) reported that in recent years there have been approximately 56,000 automobile crashes annually in which driver drowsiness was cited by police as the main cause. An annual average of 40,000 resulted in nonfatal injuries and 1,550 in fatalities. Furthermore, 70% of all drivers have admitted to driving while they were drowsy.

Our goal is the prevention of these accidents by developing a compact, automated apparatus that is capable of accurately monitoring driver drowsiness in real time. Meeting this goal requires that the system be non-invasive as driver inconvenience is minimized. We considered various methods to monitor driver drowsiness and to observe the biological function of sleep using a computerized system. Each method was examined for its strengths and drawbacks, while keeping feasibility and cost issues in mind.

II. Driver Alertness

A technique for the assessment of a driver's alertness is by analyzing brain waves. Humans emit unique brain wave patterns when they are drowsy. Through detection of these patterns, a highly accurate measure of a person's alertness can be achieved.

As a solution for the CarSitter, however, the EEG was discarded as a viable option. Electrodes must be placed at specific points on the individual's head to monitor the microvolt signals of the brain effectively. The instrumentation needed for this procedure required an investment of at least $1000 for a low-end EEG device. So, along with the invasiveness of this procedure, budgetary restrictions eliminated the EEG as a possible choice.

An analysis of driver steering patterns also offered an intriguing solution. This system is based on the hypothesis that drivers have to make slight steering adjustments while driving on a highway. For an alert driver, these movements will be precise and small in amplitude, whereas for a drowsy driver these movements will be less precise and larger in amplitude.

In a similar fashion, the time intervals between steering adjustments were examined by Fukada, Akutsu, and Aoki for Toyota. They hypothesize that a drowsy driver takes longer to recognize and also to respond to events. The time intervals between making steering adjustments will be noticeably longer for a drowsy individual than that of an alert driver.

Allowing for the accurate detection of driver drowsiness, both methods offer a non-invasive and inexpensive means to record driver steering data. Requiring only sensors in the steering wheel and a processor to analyze the data, a device may be developed with either procedure to identify a drowsy driver.

III. Advantages

Despite the advantages that steering monitoring methods offer, these systems only apply to highway driving. Even though most drowsy driving accidents occur on the highway, our objective is to create a flexible system which can be universally applied to highway and non-highway driving situations.

After considering various solutions, we decided to focus on monitoring the eyes of the driver. Many studies have revealed a significant correlation between eye behavior and drowsiness. Along with its application to both local and highway driving, analyzing the appearance of the eye offers a non-invasive and universal means to gauge driver alertness. Various measurements we considered included pupil size, eye-inclinations, and eye-blink rate. Each of these methods requires the use of a camera to monitor the eyes. We ultimately decided to reject the use of pupil size and eye-inclination techniques. Each driver would require re-calibration of the system since these features vary from driver to driver. Also, to accurately monitor them would require using a high-resolution camera.

We decided to implement the monitoring of eye blinking as our method of drowsiness detection. The normal blinking rate for an alert individual is 20 blinks per minute, each lasting about 0.25 seconds. For a driver in a drowsy state, the blinking rate reduces to about 10 blinks per minute as blink duration doubles to 0.5 seconds.

However, there are some drawbacks to measuring blink rate. As drivers use different seat positions and move their heads while driving, the system must account for the changing location of the driver's eyes. The device also must be fast enough to measure blink rate in real time. Furthermore, the solution should consider drivers who start off drowsy and adjust the blink rate threshold accordingly.

To develop this solution in an efficient manner, we have subdivided our group into two teams of two. One team is handling the hardware implementation while the other team proceeds with software development. As the hardware portion of the solution obtains the image of the driver, the software will process the information to evaluate the driver's level of alertness.

The setup we are implementing is explained as follows. It comprises of a camera with two rings of infrared LED's in the same plane as the camera lens, as shown in Fig. 1. The inner ring is directly adjacent to the camera lens while the outer ring is some distance away, dependent on the distance to the driver. The purpose of the inner ring is to produce the "red-eye" effect seen in photographs. When the inner ring is on, the pupils reflect the infrared light and appear bright (a "bright eye" image).

When the outer ring is lit, the pupil appears dull while the rest of the face appears bright (a "dark eye" image). These responses are unique to the human eye and any other objects viewed by the camera will not produce such an effect. Therefore, if the infrared LED rings are synchronized with alternating frames of the camera, the "bright eye" and "dark eye" images can be subtracted using image processing techniques, resulting in an image containing two spots which represent the pupils of the eyes. To prevent ambient light from interfering with the red-eye effect, we employed an IR filter on the lens, which filters out all wavelengths between 400-700 nm. As Fig. 2 illustrates, difference imaging allows for the pupils to be isolated from rest of the frame.

As the driver blinks, the spots corresponding to his pupils will decrease in size and blinks can be detected. The purpose of the outer ring is that in the "bright eye" image, some other features of the face might reflect light back to the camera. Since the "dark eye" image makes these regions much brighter than the "bright eye" image, those regions are removed from the resulting difference image.

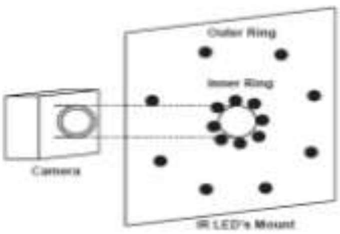

Fig. 1: Camera with inner and outer rings of LED's

We are developing software for the CarSitter to process the streaming video coming from the camera. Pupil isolation is accomplished by running a line-by-line sweep on the pixel values of two successive frames, stored for the duration of the image subtraction. The resulting image is then scanned in search of high-intensity pixel values. We chose a monochrome camera to avoid processing the extra color information, thereby simplifying the analysis. When the driver's eyes are open, two bright spots indicate the pupils are present. When the driver's eyes are closed, there will be no bright spots. These data will be used to determine the driver's blink rate. Feeding this information into another algorithm, a decision will be made which evaluates the driver's level of drowsiness.

IV. Simulation Results

Fig. 2: Sample Difference Image from our setup

One objective for the hardware system is to maximize the number of pixels of the pupils, so that the software can evaluate the blinking rate accurately. Using vari-focal zoom lenses, we can maximize the size of the pupil in the frames sent to the image processing software. We are also implementing a setup that will track the motion of the driver's eyes to ensure the pupils of the driver are in the center of the frame.

After the image processing has found the location of the pupils, the software sends control signals to the hardware system to adjust the position of the camera. Currently, a combination of actuators, motors, and control drivers accomplishes the task of moving the camera setup. Having the driver's head in the center of the frame allows for maximum data obtained about the driver's pupils.

The CarSitter solution is accomplished by mounting the apparatus on the dashboard of the vehicle to provide an optimal view of the driver's face without impeding his vision. The infrared LED's will not be a distraction and are not harmful to the driver. While the camera obtains useful data, the software of the CarSitter is used to determine the driver's blink rate. The CarSitter will continue to operate so long as the vehicle is running.

It will be flexible enough to deal with situations which may impede accuracy, such as dropped frames by the camera or if the driver briefly moves out of the camera's field of vision. We hope that, by the end of our project, our prototype will be of immediate use in the effort to keep drivers and their passengers safe from harm. Thus, an efficient method of car sitting mechanism is shown in this paper. The pictures of our current set up is shown below.

V. Experimental Set-Ups

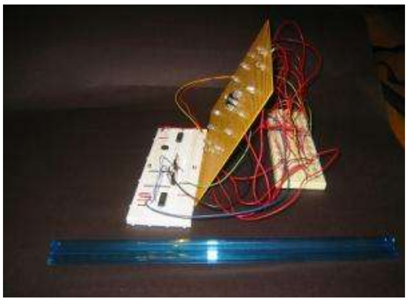

Fig. 3. Side view of current setup

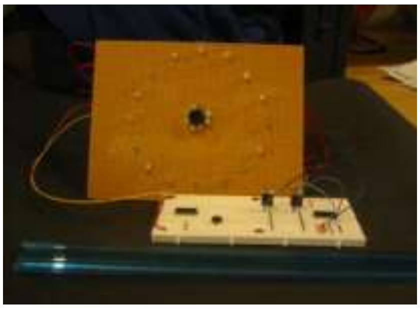

Fig. 4: Front view of current set up

VI. Conclusions

In this research paper, an automatic steering mechanism design using brain networks with hardware implementation is carried out. The practical or the experimental results presented shows the effectiveness of the methodology developed.

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