Driver Drowsiness Detection Based on Humantenna Effect for Automotive Safety Systems

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***Abstract*—Car accidents due to driver drowsiness are a major concern for the automotive industry, hence, great effort and budget are invested towards advanced automotive safety. A wide range of sensors are currently being considered in automotive safety. The majority of these sensors are intended for biological measurements such as respiration activity, heartbeat, blood's alcohol concentration, etc. System complexity and implementation cost are some of the challenging design requirements, which affect the widespread usage of such sensors. In this paper, a simple and inexpensive passive touch sensor based on the humantenna effect is proposed and tested to detect driver drowsiness.**

Keywords*—*Automotive safety, drowsiness detection, human touch sensor

I. Introduction

Drowsy driving is one of the most dangerous distracted driving patterns and considered as a permanent cause of injuries and deaths [1]. According to the European E-survey of road user's attitudes (ESRA), most surveys concluded that the driver who suffers drowsiness is seen as a main cause of accidents. Moreover, about 36% of motorway accidents in Europe is attributed to driver drowsiness [2]. Currently, the automotive industry is paying great attention to equip vehicles with new integrated safety features. These features include collision avoidance, pedestrian warning, lane change detection, driver feedback and even semi-autonomous driving, among others. As technology advances, the vehicle could now engage to alert for dangerous behaviour using advanced sensors built into the vehicle such as camera based sensors, and depth-based sensors [3]. However, these systems have many challenges that could affect their functionality. For instance, camera-based sensors suffer from variations in light, colour and background and require huge computational cost due to massive image processing, while the depth-based sensors cannot identify the orientation and the shape of the hand [4]. Nowadays, the automotive industry tries to minimize the car accidents by integrating biosensors such as heart and respiration in-car embedded nonintrusive sensors [5], and automotive Guttersberg sensors [6] shown in Fig. 1. The heart and respiration in-car embedded nonintrusive sensors (HARKEN) are based on the detection of cardiac and respiratory rhythms through embedded sensors in driver's seat and seat belt [5]. In Guttersberg sensor[6], the drowsiness detection is done using flexible sensor or bent sensor that measures the amount of bending. However, the performance of the sensor is highly dependent on the temperature. Hence, it is required to evaluate the values of the resistance along several areas of the steering wheel. In DADSS [7], driver alcohol detection system for safety, a new approach to measure the concentration of the blood alcohol is introduced. Its operation principle is based on a touch-sensing system that uses spectroscopy in order to measure blood alcohol concentration in the tissues of the driver's hand. However, it takes more than 2 hours in order to detect the alcohol concentration and additionally it can't detect driver drowsiness, which doesn't involve alcohol. This paper presents a cost-effective touch sensor integrated within the whole surface area of the steering wheel. This integrated touch sensor is based on humantenna operation principle [8] that can detect the presence of human hand on the steering wheel.

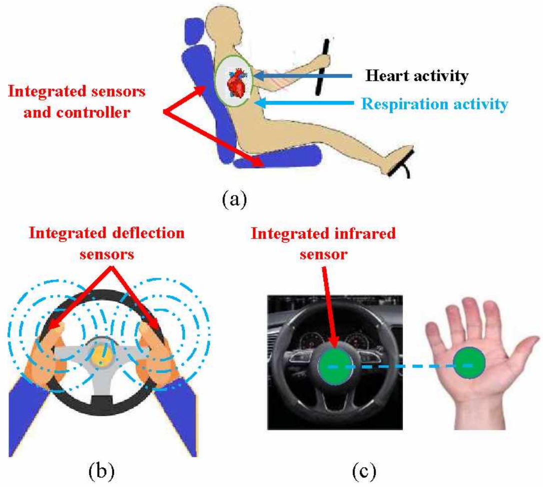

Fig. 1. Schematics of some available automotive safety sensors. (a) HARKEN [5], (b) Guttersberg [6], (c) DADSS [7].

II. Operation Principle and Design

As the human body contains several minerals, it exhibits good conducting characteristics and hence it can be considered as an antenna. Background extremely low frequency (ELF) magnetic fields are usually induced from any AC source in proximity. Faraday's law can describe this mutual relation:

$$\oint \vec{E}.\vec{ds} = \frac{d\Phi_B}{dt} \qquad (1)$$

where Φ_B and E are the magnetic and electric fields respectively. Therefore, there will be an induced electric field on the human body due to the surrounding 50/60 Hz AC power lines. This induced voltage v_{hl} can be expressed as [9]:

$$v_{hl} = \frac{Z_{hg}}{Z_{hg}+Z_{hl}} V_l \qquad (2)$$

where z_{hg} is the impedance seen between the human body and the ground and z_{hl} is the impedance between the line and the

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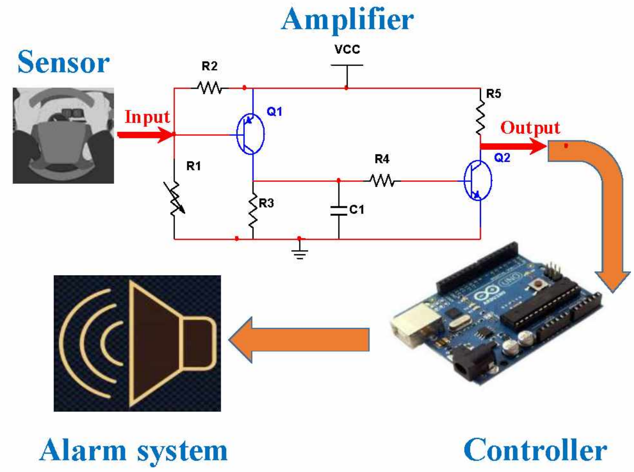

Fig. 2. Schematic of the proposed signal processing stage.

human body while v_l is the AC power line of 50/60Hz and 220V. The main idea of the proposed sensor is to harvest this induced voltage, which changes with the strength of hand grip on the driving wheel. The sensor is designed to yield a higher voltage value in case of loose hand grip, i.e., indication of driver drowsiness, and then an alarm system is activated as a warning for the driver. Figure 2 shows a schematic of the proposed signal processing stage including an amplifier composed of 2 bipolar junction transistors (BJTs) to produce the necessary voltage gain to activate the microcontroller.

III. Experimentation and Results

The experimental setup of the proposed system is shown in Fig. 3. The touch sensor is integrated within the whole surface area of the steering wheel by rolling the wire electrodes over its area. The controller and the alarm system should be placed somewhere in proximity to the driving wheel. In case of driver drowsiness, the hand grip on the steering wheel tends to be loose, which produces weaker touching effect and hence the controller identifies drowsiness event triggering an alarm to warn the driver. Several experiments are carried out to find the effect of hand grip pattern of the driver on the output voltage of the system. The grip strength is classified on a scale from 0 to 5, where scale 0 refers to loose or no grip and scale 5 refers to a tight grip. Four volunteers (2 males and 2 females) have agreed to participate in these experiments. Figure 4 illustrates the relation between the grip strength and the corresponding output voltage. It can be clearly seen that the grip strength can be distinguished based on the value of the output voltage. Accordingly, in case of driver drowsiness, the driving wheel grip becomes loose as the driver starts to lose control, which corresponds to the highest output voltage indicating driver drowsiness.

IV. Conclusion

In this paper, a novel system for driver drowsiness detection based on humantenna effect was proposed to be equipped in automotive safety applications. The proposed sensor is easily integrated within the surface area of the driving wheel with no need for special equipment or arrangement. Based on the strength of hand grip on the driving wheel, a corresponding induced voltage is recorded indicating the status of drowsiness. Different grip patterns for different male and female individuals have been examined. The measured induced voltage was proved to be an effective

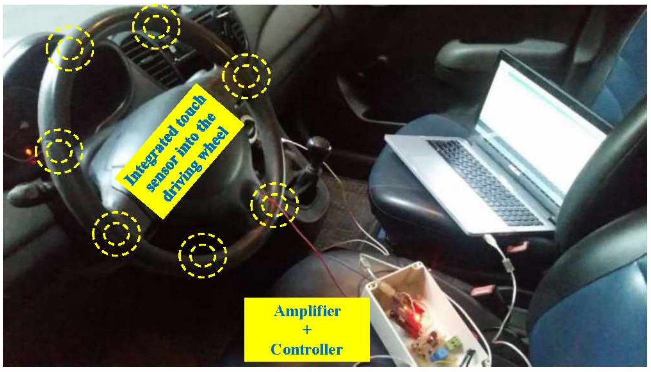

Fig. 3. Experimental setup of the proposed system installed on car.

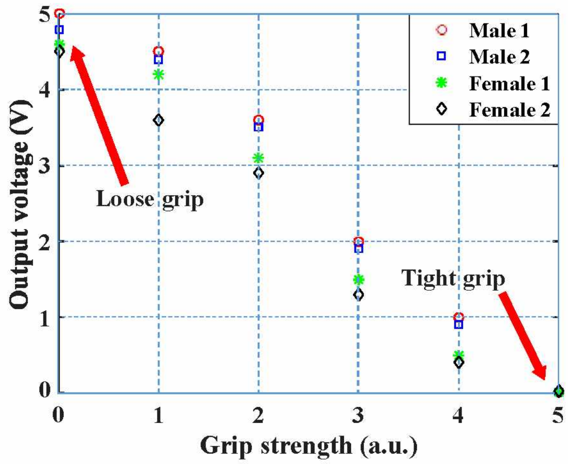

Fig. 4. Induced voltage from different steering wheel grip patterns.

indicator of grip strength on the driving wheel and hence drowsiness detection. In addition to its cost effectiveness and simplicity, this sensor is passive requiring no receiver or transmitter.

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