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An application of wireless brain–computer interface for drowsiness detection

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ABSTRACT

Wirelessly networked systems of sensors could enable revolutionary applications at the intersection of biomedical science, networking and control systems. It has a strong potential to take ahead the applications of wireless sensor networks. In this paper, a wireless brain computer interface (BCI) framework for drowsiness detection is proposed, which uses electroencephalogram (EEG) signals produced from the brain wave sensors. The proposed BCI framework comprises of a braincap containing EEG sensors, wireless signal acquisition unit and a signal processing unit. The signal processing unit continuously monitor the preprocessed EEG signals and to trigger a warning tone if a drowsy state happens. This experimental setup provides longer time EEG monitoring and drowsiness detection by incorporating the clustering mechanism into the wireless networks.

1. Introduction

Body area networks (BAN), typically understood as networks of wearable wireless devices designed to enhance clinical applications, have received considerable attention in the last few years. Even more intriguing is, however, the fascinating promise of a future where carefully engineered miniaturized biomedical devices implanted or ingested by humans are wirelessly internetworked to collect diagnostic information and to fine-tune medical treatments or biomedical applications over extended periods of time [1]. Drivers tiredness has been embroiled as a causal element in numerous mischance due to the stamped decrease in drivers' ability to detect danger and distinguishment of risk [2,3]. Drowsiness is move state in the middle of getting up and slumber, amid which a diminishing of vigilance is achieved. Drowsy driver recognition framework is one of the potential applications of intelligent vehicle systems [4,5]. The National Highway Traffic Safety Administration (NHTSA) reported that drowsy driving causes more than 100,000 accidents a year, bringing about 40,000 wounds and 1550 passing [6]. As per a study from National Sleep Foundation (NSF), 37 percent of individuals said that, they had fallen asleep at the wheel, and 13 percent said they did so once a month. Youthful grown-ups aging 18–29 are more inclined to say they have driven drowsy (71 percent), contrasted with generally 50% of grown-ups aging 30–64. To be sure, it is evaluated that more youthful drivers represent very

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nearly two-thirds of drowsy driving accidents. Men are more prone to drive drowsy than ladies (56 versus 45 percent) and are very nearly twice as prone to nod off at the wheel [7].

Previous studies have proposed various strategies to discover drowsiness driving by focusing on blink rate, eye closure, and inclination of driver's head. There are a few signs of drowsiness that ought to advise a driver to stop and rest. It is watched that, the parameter like overwhelming eyelids are effectively fluctuating in distinctive vehicle sorts and driving conditions [8]. The primary focus on measuring physical changes of the driver, such as pulse rate, heartbeat rate, eye blinking measures and electroencephalographic (EEG) activities to detect drowsiness and alert the driver before meeting an accident [9]. Orden et al. [10] showed the comparison between the EEG based methods with the eye-activity based method for detection of drowsy driving.

This paper proposes, a quick distinguished EEG-based wireless brain computer interface (BCI) scheme for drowsiness detection. There are a couple of studies as per the compact BCI contraption for wired or wireless correspondence. The proposed wireless BCI model comprises of a braincap, signal acquisition unit and a signal processing unit. The signal acquisition unit is installed in a braincap, which is continuously worn by the driver, when driving. Here, the braincap shown in Fig. 1 is utilized to gather EEG signals continuously and transmit them to the signal processing unit wirelessly. The signal processing unit, placed at the base station continuously catches the drowsiness and triggers a cautioning tone to counteract crashes when drowsy state happens.

The rest of the paper is organized as follows. The detailed description of the proposed BCI system is illustrated in Section 2. The network model of the drowsiness detection algorithm is introduced in Section 3. Where as, Section 4 describes the drowsiness detection process and gives warning signal when it is needed. The experimental results are discussed and efficiency is compared with other BCI systems in Section 5. Finally, Section 6 concludes the paper.

2. System modeling

The working model of the proposed wireless BCI system is shown in Fig. 2. The brain signals are captured through the braincap mounted EEG sensors. The EEG signal acquisition unit (SAU) is responsible for getting the signal from the braincap and it will send digital information to the signal processing unit (SPU). Then, it is the job of the SPU to take decision, whether warning tone should be triggered or not. The two parts of the SAU are analog and digital. In the analog stage, bandwidth filtering and amplification are two main components needed for getting robust and reliable signal. Due to the low amplitude of the EEG signal, amplification is very much needed before further processing.

Furthermore, a clustering algorithm is used for the total number of sensors used in the braincap. In this phase, on the basis of geographical information and the energy power of the sensors the cluster heads (CH) are selected periodically. The CHs are responsible for sending the sensed data to the base station (BS). In this way, we can save the energy of the cluster member nodes for increasing the lifetime of the network. After the selection of the CHs, the neighbor nodes try to become a member of the cluster by sending request information. Then the CHs decide which member nodes will be a part that corresponding cluster. When a sensor node is inducted as a cluster member for any one cluster, it cannot be considered for any other. After the end of the clustering process if any node stays alone without becoming a member of any cluster, then it becomes a cluster head.

2.1. *Wireless EEG signal acquisition unit*

The drivers wear the braincap as shown in Fig. 1(a), and the signals are acquired from the electrodes. The signal is recorded as unipolar by taking the left ear as a reference point. EEG signals are recorded at a sampling rate of 256 Hz utilizing

(a)

(b)

Fig. 1 – (a) Wireless braincap and (b) signal processing module.