The design and development of wireless blinking detection system using EOG technique

REPORT OF RESEARCH RESULTS

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Summary

A low-cost blinking detection system was built with simple modules and acceptable performance by measuring the EOG signal from one low-pass filter. Results from the preliminary experiments suggest that the blinking detection system can work just fine under controlled conditions such as in a laboratory setting. However, this blinking detection system has some technical issues that need to be resolved (ie – an automatic blinking detection system, the instability of the signal, the use of electrodes, etc). There are some limitations on using this blinking detection system. Examples are (1) decision parameter needs to be adjusted by the users, (2) the electrode itself (ie – the size, the wireless system, etc) is in need for the further development of blinking detection system, etc. For the future research on road safety improvement, the new design blinking detection system should be developed for the ease of use, the installation in a driving simulator and/or a real vehicle, and the test as an in-vehicle warning system to protect drowsy drivers.

Aims of research

1. To develop an in-vehicle warning system – focusing on drowsy driver.
2. To provide a better understanding of driver's behavior in order to prevent them from falling asleep while driving.
3. To make recommendations for future actions on drowsy driving prevention

Methods of Research & Progression

In this study, a new design for the EOG detection system is presented in Fig. 1. The EOG signal is measured using electrodes that have been placed at three positions around the eye of the subject. The EOG signal is pre-processed by the amplifier circuit and sent out to microcontroller for the second-processed. The processed signal is transmitted to a personal computer for motoring and doing data analysis via a wireless transmission unit.

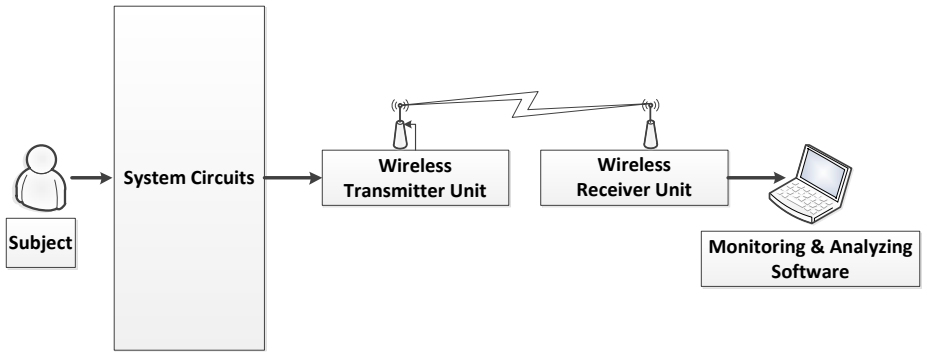

Fig. 1. A connection of a new design for EOG detection system.

This blinking detection system is composed of three major components as follows:

A. The EOG hardware

Regarding the design of the EOG hardware, we focus on concepts of making and maintenance it with low costs, and achieving an acceptable quality of signal. The dimension of EOG hardware excluded battery is about 5 cm x 8 cm x 3 cm, as shown in Fig. 2. The EOG system operates at 175.164 mW with 3.7-V DC power supply. This module can operate for over 11 hrs. with a 2000 mAh Li-ion battery. The hardware consists of three different modules: an amplifier circuit, a microcontroller and a wireless transmitter unit, as given in details later. First, the amplifier circuit has a low power instrumentation amplifier (INA118) and a low-pass filter. The gain of the amplifier circuit is at 500 times. Second, microcontroller (Fio-Std) receives the amplified signal of 12 bit analog-to-digital converter (ADC) with a sampling rate of 200 Hz. This microcontroller has a great advantage of taking a low power consumption due to ARM 32-bits CortexTM – M3 Processor (STM32F103RET6), the built-in RapidSTM 32 native-support boot loader, 496 Kbytes available flash memory, high capacitance (0.33F) capacitor as RTC backup battery and C code support generation of a custom user program for STM32 from a MATLAB Simulink model, to process the amplified signal and send EOG signal to wireless transmitter unit. Third, the wireless transmitter module (Xbee) is used as a wireless transmission/receive unit. Since the wireless unit operates at high-frequency band (2.4 GHz) to transmit data wirelessly, it can work just fine by using an internal printed-circuit board (PCB) antenna with the data transmission rates of up to 200 kbps.

B. EOG Signal Processing Process

After the amplified signal has been passed to the microcontroller via ADC, the next step is the digital signal processing. With the advantages of using a built-in RapidSTM32 native-support boot loader in Fio-Std microcontroller, it can support C code generation of a custom user program for STM32 from a MATLAB Simulink model.

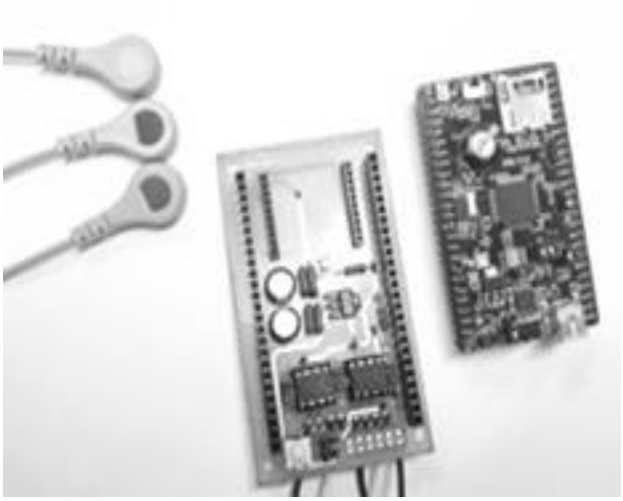

Fig. 2. The EOG hardware

C. Blinking Detection Algorithm

At the end of a signal processing process, the processed signal is transmitted to the personal computer via wireless transmission unit (Xbee) to analyze eye blinks. This blinking detection system works under the design and analysis of mathematical functions, time domain. The detection method uses the first derived amplitude of the EOG signal in vertical interval as a decision parameter, making some adjustment by users/analyzers. An example of the peak blinking detection on the base of the first derivative is presented in Fig. 3.

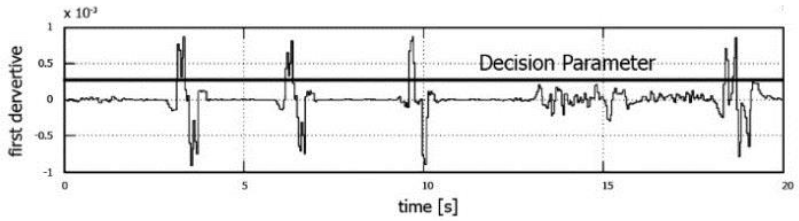

Fig. 3. The EOG signal as a decision parameter

D. Experiments

All experiments in this research were run in a laboratory setting. Decision parameters are manipulated by an experimenter. In these preliminary experiments, a total of 5 participants (3 males and 2 females) were tested. The purpose of the experiment was to investigate the ability of a blinking detection system that would work under controlled conditions. Each experiment ran for 30 minutes on each participant.

E. Results

Results from the current study suggest that the EOG system can detect eye blinks at the time when the blink occurs. The blinking detection system works pretty well when the EOG signal parameter is greater than other setting decision parameters. The system can display, record and lead to a personal interpretation in a real time manner. This may be concluded that the EOG detection system can work just fine under a controlled condition. However, limitations of using the system have been found during the experiments and are needed to mention for this study. A simple example is the facial skin condition of the subject that needs to be clean before placing electrodes.

Results of Research

In this research, we design and develop the low-cost wireless blinking detection system using EOG technique. We are developing this blinking detection system to prevent road traffic accidents caused from drowsy drivers.

Future Areas to Take Note of, and Going Forward

Currently, we are developing the new algorithm for an automatic signal adjustment. This can help an analyzer make an accurate decision making on the signal. We are also trying to design and build a new wireless electrode system in a tiny size where it can be installed in the flame of glasses. This could be applied for the use of the blinking detection system in real driving conditions.

Means of Official Announcement of Research Results

This low-cost system is developed to prevent deaths, injuries, and financial losses due to drowsy driving. In the future, this kind of system might be installed in vehicles. However, the development of the system is in need. Researchers need more financial supports from public or private sectors. This research could not be done without the financial support from the Mitsui Sumitomo Insurance Welfare Foundation. This research grant means so much for our current and future research projects. Thank you very much!!!