JINS MEME Algorithm for Estimation and Tracking of Concentration of Users

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Abstract

Activity tracking using a wearable device is an emerging research field. Large-scale studies on activity tracking performed with eyewear-type wearable devices remains a challenging area owing to the negative effect such devices have on users' looks. To cope with this challenge, JINS Inc., an eyewear retailer in Japan, has developed a state-of-the-art smart eyewear called JINS MEME. The design of JINS MEME is almost the same as that of Wellington-type eyeglasses so that people can use it in their daily lives. JINS MEME is equipped with sensors to detect a user's eye movement and head motion. In addition to these functions of JINS MEME, JINS developed an application to measure concentration levels of users. In this demonstration, users will experience wearing the JINS MEME glasses and their concentration will be measured while they perform a certain task at our booth.

Author Keywords

Wearable device; Eyewear; Activity tracking; Eye Blink; Electrooculography

ACM Classification Keywords

H.5.3. Information interfaces and presentation (e.g., HCI): Group and Organization Interface

Figure 1: Hardware design of the JINS MEME eyeglasses.

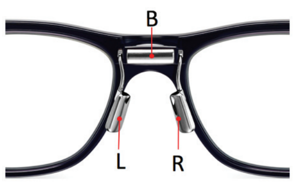


Figure 2: Electrodes built in the nose pad and bridge.

Introduction

A variety of wearable devices are emerging, and researchers are conducting large-scale studies using many of these devices. Rachel et al. studied physical activity and sleep in student population using 500 Fitbit Charge HR devices [1]. Watch-type devices are often employed for large-scale studies, taking advantage of the robustness of such devices and their minimum interference to users. On the other hand, to the best of our knowledge, no practical large-scale study using eyeglass-type devices has been conducted. Mary et al. conducted a trend survey of wearable devices and reported that the application ratio of eyeglass-type wearable devices is about 3% while that of watch-type devices is 30% [2]. This is possibly because of the fact that eyeglass-type devices directly affect users' looks, in most cases in an adverse manner. In this paper, we describe an eyeglass-type wearable device designed for daily use and its application to estimate the concentration levels of users.

JINS MEME

JINS MEME, shown in Figure 1, is a commercially available smart eyewear that allows detection of eye movements and head motion. Some studies have been performed using the JINS MEME glasses [3].

Eye movements including blinks are detected by the electrooculography sensor built in the nose pads and bridge of the eyewear, as shown in Figure 2. The temple end of the frame contains a lithium-ion battery and an MPU-6500 six-axis (accelerometer and gyroscope) sensor. Eye movements are calculated as follows [4]:

$$V_{vertical} = -(V_L + V_R)/2\,, \tag{1}$$

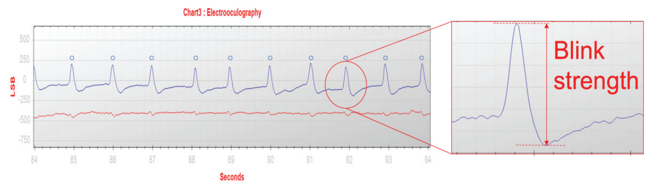
$$V_{horizontal} = V_L - V_R\,, \tag{2}$$

where $V_{vertical}$ is the up-down eye movement, $V_{horizontal}$ is the side-to-side eye movement, V_L is the potential between electrodes L and B (Figure 2), and V_R is the potential between electrodes R and B. Equations (1) and (2) are derived under the presumption that eye balls move in the same direction. As a consequence, JINS MEME is not able to detect simultaneous inward movement of both eyes that is technically called convergence.

Eye blinks are vertical eye movements known as Bell's phenomenon. The blue line in Figure 3 (a) is an electrooculogram and the blink signal is blown up 10 times. Each blink is represented by a spiky peak on the signal shown by the blue line that indicates vertical movements of the eye. We define the peak-to-peak value as the "blink strength" shown in Figure 3 (b). The red line indicates the output of the sensor corresponding to the side-to-side eye movements. Kanoh et al. reported that the blink detection accuracy of the JINS MEME eyeglass is above 90% in the lab setup [4]. Nathaniel et al. tested the eyeglass in another setup and reported that the blink detection accuracy is nearly 98% [5].

In our work, we used blinks as a key parameter to estimate a user's concentration level. Head posture is also considered as a parameter associated with the concentration level.

Figure 4: User interface of the office application.



(a) (b)

Figure 3: (a) Electrooculogram showing 10 peaks corresponding to the user's blinks. The signal is blown up 10 times. (b) Signal corresponding to one blink and a simple definition of blink strenth.

Application to measure concentration level

The JINS MEME Office App, one of the official applications for the JINS MEME device, measures a user's concentration level. In this research, we define "concentration level" to indicate how deeply a user works on a single task such as creating a document on a PC. Therefore, concentration levels when a user performs parallel tasks are not included in the scope of our work.

The JINS MEME Office App calculates the concentration level based on 1) blink rate, 2) blink strength, and 3) head posture. Blink rate is a typical parameter used to understand a person's cognitive load. It is well known that blinks are divided into three types [6]: (a) reflex blinks, (b) voluntary blinks, and (c) endogenous blinks. Among these blink types, endogenous blinks are the key factor associated with a user's cognitive states. Many studies have concluded supporting the fact that the more attention necessary, the fewer blinks occur [6]. Blink strength and head posture are other parameters considered important indicators of concentration, based on our preliminary studies and observations of subjects. Calculating the concentration level is performed in steps. First, using the blink rate, blink strength, and head posture, we calculate three relevant parameters, namely Focus, Calmness, and Posture, which are integers having a value between 0 and 100. We defined these parameters: (i) Focus is a function of blink rate, (ii) Calmness is a function of blink strength, and (iii) Posture is a function of posture. The concentration level is calculated as an average of Focus, Calmness, and Posture.

We developed an iOS application that shows the result of the calculation, which was explained above. For instance, in Figure 4, the average concentration value calculated (86 out of 100), and the time-series variation of the concentration level are shown. The red-colored part indicates the duration when the user's concentration level is higher. The update frequency of those values is approximately 20 Hz, and therefore, the user can see the continuously updated values while his/her concentration levels are measured during the demonstration. Figure 5 shows example values of Focus, Calmness, Posture, and Concentration level.

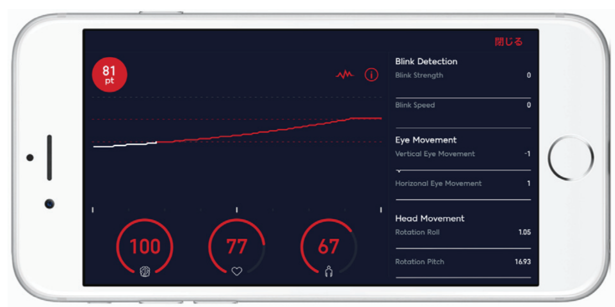


Figure 5: Skin of application showing a concentration value of 81 at top left, and other values (Focus = 100, Calmness = 77, Posture = 67).

Pilot study

We used the application that we developed and conducted a pilot study to explore the differences in concentration levels caused by the working environment. In this pilot study, we selected four places where users were asked to do a document-related task on their laptops. A regular workplace was selected as control, and the other three places were a park, cafe, and co–working space. Three subjects participated in this experiment and each of them performed the document-related task with their laptops for approximately 30 min in each place. Table 1 presents the result of the estimated average concentration levels during the experiment.

User	Office	Park	Cafe	Co-work space
A	55	70	63	62
B	45	48	64	64
C	47	53	54	59
Average	49	57	60.3	61.8

Table 1: Result of the estimated concentration level.

In the pilot study, the average concentration level values measured at the office, which is the regular working place, was the lowest. Even though, among these few participants, the average concentration level is not satisfactory in terms of the t-test, this result agrees well with our prediction. As described above, this application was developed with the objective of measuring a user's concentration level during a single task. There is a high possibility of a user being interrupted by colleagues at work. Hence, the average concentration value would be lower than that in other cases.

Acknowledgement

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