World Automation Congress © 2010 TSI Press.

MOUSE CURSOR CONTROL SYSTEM USING ELECTROOCULOGRAM SIGNALS

HIROKI TAMURA † *, MASAKI MIYASHITA † , KOICHI TANNO † AND YASUSHI FUSE ‡

† *Faculty of Engineering, University of Miyazaki*
Miyazaki, 889-2192 JAPAN
**htamura@cc.miyazaki-u.ac.jp*

‡ *Miyazaki Prefecture Industrial Technology Center*
Miyazaki, 880-0303 JAPAN

ABSTRACT—The aim of this study is to present electrooculogram signals that can be used for human computer interface efficiently. Establishing an efficient alternative channel for communication without overt speech and hand movements is important to increase the quality of life for patients suffering from Amyotrophic Lateral Sclerosis or other illnesses that prevent correct limb and facial muscular responses. Using electrooculogram signals, it is possible to improve the communication abilities of those patients who can move their eyes.

In this paper, we introduce the mouse cursor control system for Amyotrophic Lateral Sclerosis patients using electrooculogram signals. We propose the algorithm corresponding to the drift. In order to test the effectiveness of our proposal system, we tried the experiments of a Japanese sentence input task using our proposal system.

Key Words: Electrooculogram Signal, Mouse Cursor Control System, Drift

1. INTRODUCTION

The movement of the eyes of the Amyotrophic Lateral Sclerosis patient remains at end stage. There are several methods that based on Eye-Gaze input interface using eye movement. Video camera method: This method is weak to external light. And the device is large dimension. Search-coil method: This method can be determined with high accuracy. But, this method needs particular contact lens, so invasiveness to the subject is high. Therefore this method can't be used for a long time. The electrooculogram (abbr. EOG) method: The system using this method can be manufactured at a low price. And the installation of the electrode is easy. In addition, this method is noninvasive. EOG method can be used for a long time.

In the eye movements, a potential across the cornea and retina exists, and it is source of EOG. EOG can be modelled by a dipole [1], and these systems can be used in medical systems. There are several EOG-based Human-Computer Interface studies in literature. A wheelchair controlled with the eye movements is developed for the disabled and elderly people. The eyes movement signals and sensor signals are combined, and both direction and acceleration are controlled [2]. Using horizontal and vertical eyes movements and two and three blinking signals a movable robot is controlled. Because the EOG signals are slightly different for the each subject, a dynamical threshold algorithm is developed [3]. In this approach, the initial threshold is compared with the dynamic range; the threshold value is renewed after each difference. According to this threshold the output signal is made 1 or 0 and afterwards it is processed. EOG, electroencephalogram (EEG) and electromyogram (EMG) signals are classified in real time, and movable robots are controlled by using artificial neural network classifier [4][5]. Investigating possibility of usage of the EOG for human-computer interface, a relation between sight angle and EOG is determined.

In the study that using EOG, method with AC (alternating-current) component of EOG is common. Because when we use DC (direct-current) component of EOG, the drift becomes big problem. So, there are many menu selection types using AC-EOG. But these types don't input consecutively. Therefore, we focus DC-EOG for the continuous control system.

In this study, we are developing the Mouse Cursor Control System for Amyotrophic Lateral Sclerosis patients using EOG signals. It was considered that the performance of pointing device using EOG was influenced from the eye blinking artifacts, the displacement of electrode positions and the drift. Our proposal EOG device did not have the problem of eye blinking artifacts and the displacement of electrode positions. But, the drift was problem. Then, we proposed the algorithm corresponding to the drift. In order to test the effectiveness of our proposal system, we tried the experiments of a Japanese sentence input task using our proposal system. The performance of the proposal EOG system is relatively good, since a Japanese 40-letter word can be written on average in 331.4 seconds.

The rest of this paper is organized into four sections. Section 2 presents the mouse cursor control system using EOG signals. Section 3 introduces our proposal algorithm. Section 4 provides the experimental results of a Japanese sentence input task. Section 5 concludes the paper.

2. MOUSE CURSOR CONTROL SYSTEM USING EOG SIGNALS

2.1 The EOG Device

In this subsection, novel EOG measurement system design is proposed. Figure 1 shows the formal scheme for the acquisition and analysis of the EOG signal for the control organization and flow of information through the system. Our proposal system is based on the five features, 1) Amplifier, 2) Low pass filter for channel 1 and 2, 3) High pass filter for channel 1, 4) A/D-convertor, and 5) mouse cursor control system. It consists of five electrodes, an A/D-convertor, a personal computer, and a monitor (Figure 1).

Horizontal and vertical eye movements are measured with two passive electrodes. 5 Ag/AgCl electrodes are used (two for each channel and one is for ground). Two channels of EOG signals can be used to recognize the eyes movement. In order to remove the more than 10Hz power line noise, the low pass filter is used. The cutoff frequency of low pass filter is 10Hz. In our proposal system, channel 3 that applies high pass filter to channel 1 is used in order to remove the DC level. The cutoff frequency of high pass filter for channel 3 is 0.2Hz.

After filtering and the amplification (about 500 times) stages, the EOG signals are digitized (16 bit) and then transferred to the personal computer. The sampling frequency of the measurement data is 1 KHz. The EOG signals are then processed by a classification algorithm which is based on the dynamic threshold algorithm and the simple moving average method. This proposal method is necessary to set the value of initial threshold of each user. The classification technique is described in next section 3.

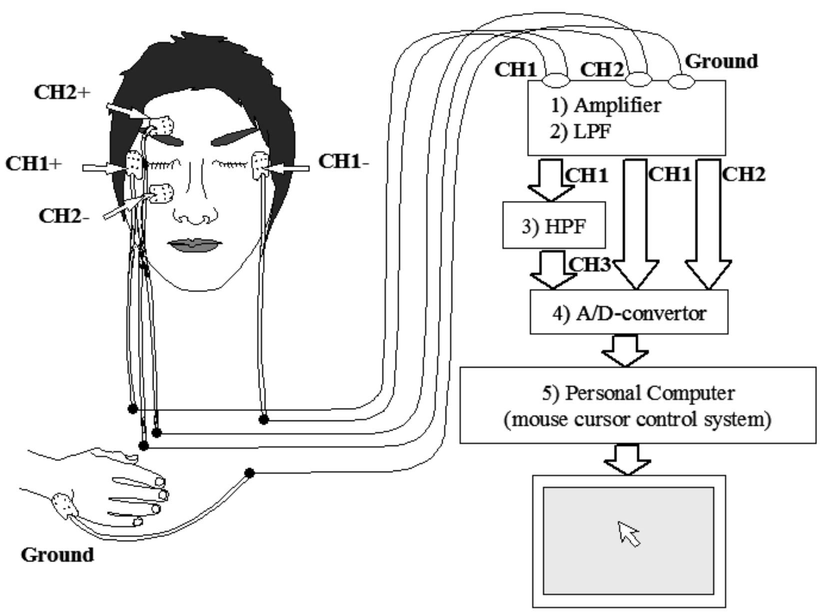


Fig 1: The Mouse Cursor Control System using EOG

2.2 *The EOG signals recording*

As seen from the recordings channel 1 and 2 in Figure 2 (the eyes movements: Right, Left, Up, Down and Lower Right), after considering noise reduction measures in designing of the biopotential data acquisition system, the EOG system performance is good. Electronic noise reduction is also successful. Figure 1 showed that 5 eyes movements are clearly different. Moreover, channel 1 and 2 have the DC level signals, so that the change of the EOG by the eyes movements continues. So, the continuous control for mouse cursor becomes possible.

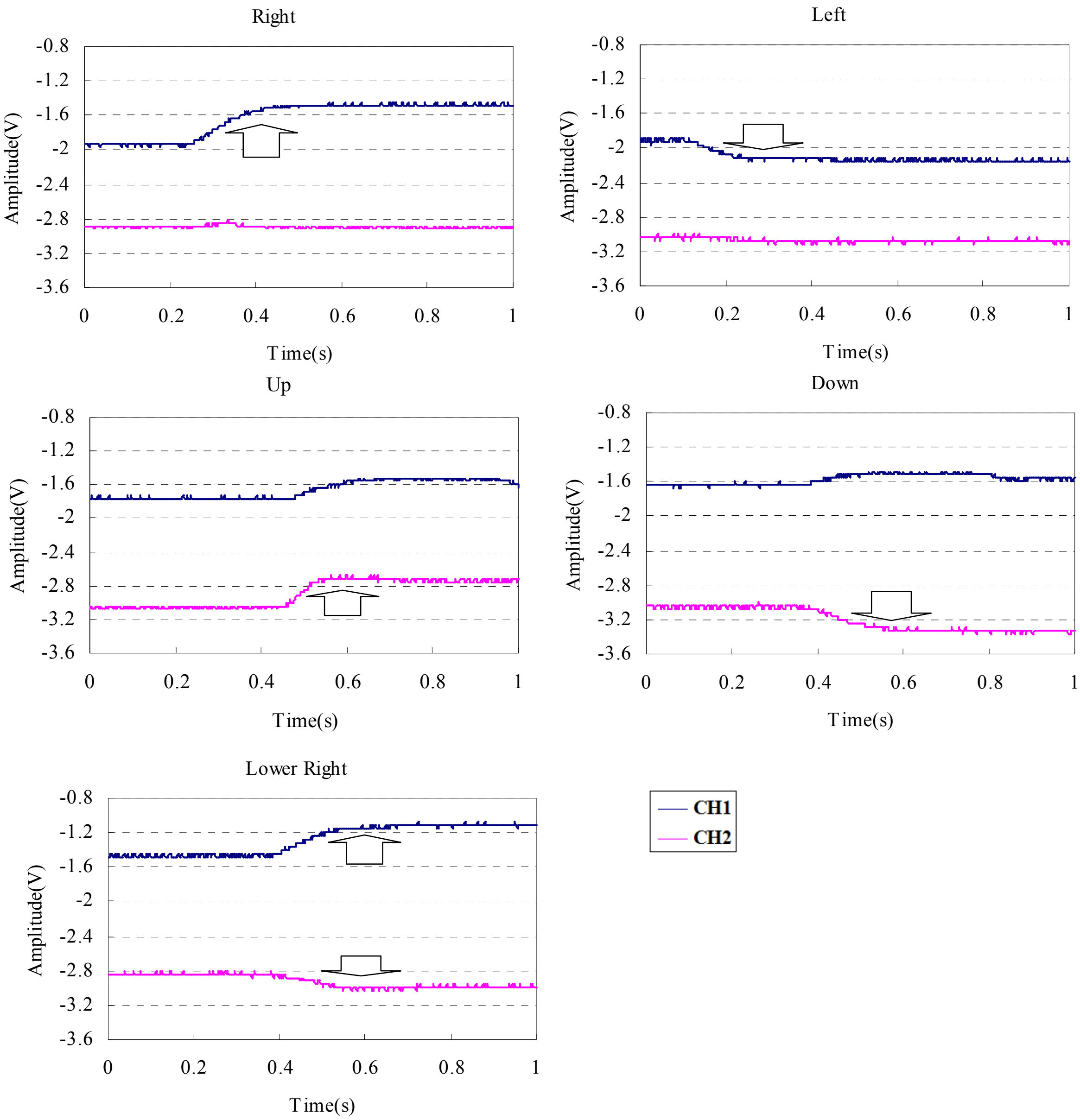


Fig 2: The EOG Signals Recording Samples in Channel 1 and 2.

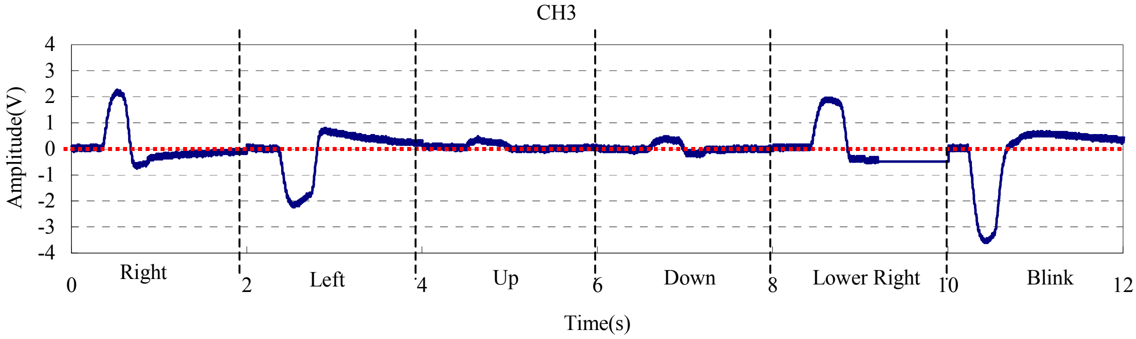


Fig 3: The EOG Signals Recording Samples in Channel 3.

From the recordings channel 3 in Figure 3 (the eyes movements: Right, Left, Up, Down, Lower Right and Intentional Blink), channel 3 signals removed the DC level by high pass filter. Therefore, channel 3 signals have the change, only when eyes move. Channel 3 signals are information that knows the difference between the change by the drift (low frequency) and the change by the eyes movements. When the channel 1 or/and channel 2 signals change without the channel 3 signal changing, this change is an influence of the drift.

3. THE PROPOSAL ALGORITHM

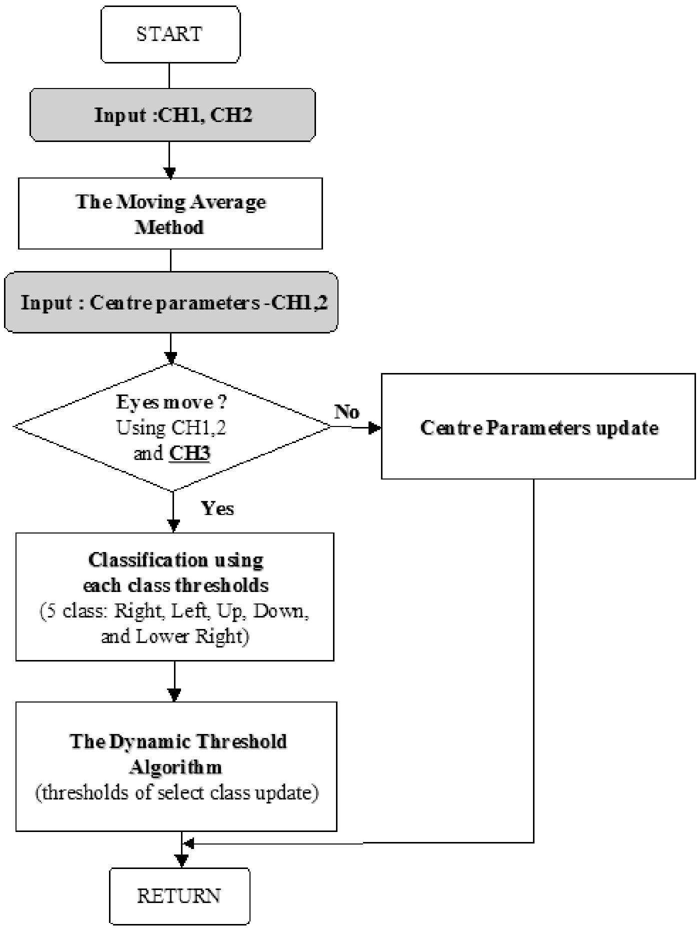


Fig 4: The Flow of Our Proposal Algorithm.

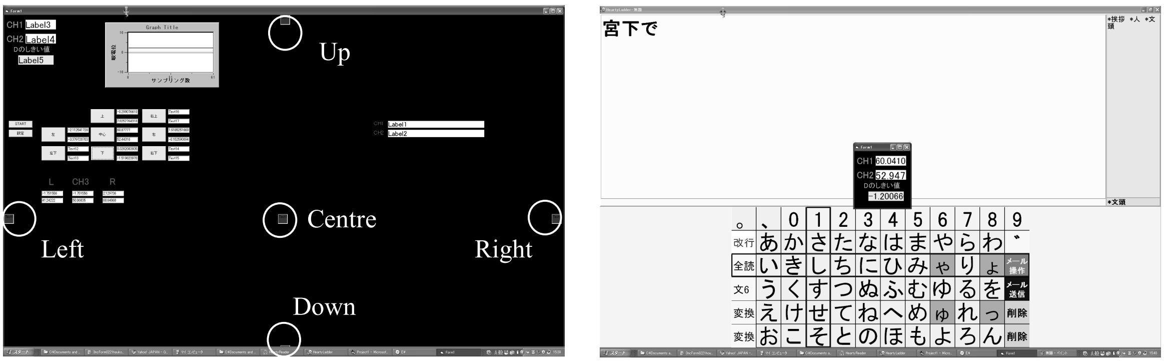
In this section, we introduce our proposal algorithm for the mouse cursor control. The initial thresholds of the eyes movement class (Right, Left, Up, Down and Lower Right) are set on the user. 4 eyes movement class (Right, Left, Up and Down) are command of the same movement of the mouse cursor. The eyes movement class of Lower Right (or voluntary blink) is a command of click processing. Moreover, the centre parameters of the eyes (centre) are set.

At first, in order to remove the more than 60Hz power line noise, we use the moving average method for channel 1 and 2. Next, the difference between the centre parameter and input (channel 1 and 2) is calculated. Our proposal system is judged whether eyes moved by using these inputs and channel 3 information. If eyes don't move, centre parameters are updated using mouse cursor position to correspond to the drift. Specifically, the threshold centre parameters of the eye are updated only using channel 1, channel 2 value in Japanese sentence input. If a total of 0.5 second of channel 3 value by which is AC component of channel 1 and channel 1, channel 2 values are smaller than threshold, the threshold centre parameters of the eye are updated in alphabet input. If eyes move, the eyes movement class is identified using each class thresholds. The value of channel 1 and channel 2 are used for identification of eye movement at the same time. And, the threshold of select class is updated according to an easy law (The Dynamic Threshold Method). These processing are repeated.

The continuous control for mouse cursor can be executed while corresponding to the drift by this proposal algorithm and proposal EOG device. Our proposal system has a big advantage from other technique using EOG.

4. EXPERIMENTAL RESULTS

In order to test the effectiveness of our proposal system, we tried the experiments of a Japanese sentence input task using our proposal system. The experimental subject was healthy man who was experienced about this system. The initialization screen and the Japanese sentence input software (Hearty Ladder [6] spec: The keyboard consists of 12 column and 6 row in Japanese sentence input. And there are 72keys in total. Similarly the keyboard consists of 10 column and 5 row in alphabet input. And it is 50keys in total.) are shown in Figure 5 (a) and (b). In this experiment, we did not use the Up command, because subject confirms the character of a monitor. The mouse cursor control interval was 0.1 seconds. We explain experiment contents. First, we calibrate to set the threshold that is necessary for analysis. Next, the subject controls mouse cursor and inputs the letter. The experiments are started from center ("Hi") on keyboard every trial.



(a) (b)

Fig 5: (a): The initialization Screen, (b): The Japanese Sentence Input Software.

Table 1: Japanese Sentence Input Tasks.

Task 1	Japanese 5-letter word	こんにちは
Task 2	Japanese 12-letter word	本日は晴天なり。
Task 3	Japanese 40-letter word	東京円、87 円台前半、14 年ぶりの円高水準に迫る。

We tried three experiments of a Japanese sentence input task (Table 1). We performed 5 trials in each task. From these experiments, an average time of task 1 was 33.4 seconds. An average time of task 2 was 111.8 seconds. And, an average time of task 3 was 331.4 seconds.

From other experiments, the average input time of the alphabet one character was about 6.6 seconds in our proposal system. The Experiments are started from ("H") on keyboard. And subject inputs key consecutively in alphabetical order. When the alphabets pass, the subject begins a new line, and starts input again. Thus the subject repeats it for one hour. Besides we made program which recover to control when the mouse cursor became uncontrollable. So if the mouse cursor became uncontrollable, the subject can continue a task. Moreover, our proposal system was able to used for continuousness one hour. From these experiment results, our proposal mouse cursor control system using EOG is a good system for amyotrophic lateral sclerosis patients and the severely handicapped human.

5. CONCLUSIONS

In this study, we are developing the mouse cursor control system for amyotrophic lateral sclerosis patients using EOG signals. We proposed the algorithm corresponding to the drift. In order to test the effectiveness of our proposal system, we tried the experiments of a Japanese sentence input task using our proposal system. The performance of the proposal EOG system is relatively good, since a Japanese 40-letter word can be written on average in 331.4 seconds. Moreover, the test in the state that lies in the bed had succeeded in the character input task. From these tests, we think that our proposal system is useful. In our future works, we plane to test the severely handicapped human.

REFERENCES

1. S. Venkataramanan, P. Prabhat, S. R. Choudhury, H. B. Nemade, and J. S. Sahambi, "Biomedical instrumentation based on Electrooculogram (EOG) signal processing and application to a hospital alarm system," in *Proceedings of the 2nd IEEE International Conference on Intelligent Sensing and Information Processing (ICISIP '05)*, pp. 535–540, Chennai,India, January 2005.
2. R. Barae, L. Boquete, and M.Mazo, "Systemfor assitedmobility using eye movements based on electrooculography," *IEEE Transaction on Neural Systems and Rehabilitation Engineering*, vol. 10, no. 4, pp. 209–218, 2002.
3. Z. Lv, X. Wu, M. Li, and C. Zhang, "Implementation of the EOG-based human computer interface system," in *Proceedings of the 2nd International Conference on Bioinformatics and Biomedical Engineering (ICBBE '08)*, pp. 2188–2191, Shanghai, China, May 2008.
4. C. K. Young and M. Sasaki, "Mobile robot control by neural network EOG gesture recognition," in *Proceedings of the 8th International Conference on Neural Information Processing*, vol.1, pp. 322–328, 2001.
5. Takao Manabe, Hiroki Tamura, Koichi Tanno, "The Control Experiments of the Electric Wheelchair using s-EMG of Facial Muscles", *Proceedings of Forum on Information Technology 2009 (FIT2009)* , pp. K-008 (CD-ROM), 2009. (Japanese)
6. Hearty Ladder, http://takaki.la.coocan.jp/hearty/