EOG Single Switch Morse code Translate Input Device for Individuals with The Motor Neuron Disease

Chung-Min Wu[1] Ke-Guei Huang[1] Shei-Hsi Chang[2] Shu-Ching Hsu[3] Ching-Ling Lin[4]

[1] Department of Electronic Engineering
Kun-Shan University, Tainan Hsien 710, Taiwan, ROC
[2] Department of Information and Communication
Kun-Shan University, Tainan Hsien 710, Taiwan, ROC
[3] Department of Special Education
National University of Tainan, Tainan 70101, Taiwan, ROC
[4] Department of Electrical Engineering
National Cheng Kung University, Tainan 70101, Taiwan, ROC

Abstract- **This study purposes to provide EOG single switch Morse code translate input device for individuals with the Motor Neuron Disease, such as Amyotrophic Lateral Sclerosis. In this study, the unstable signal is transformed to standard logic level by EOG baseline tracing algorithm in the Microprocessor, and the outputs unstable Morse code sequences are recognized by the sliding fuzzy recognition algorithm. The results demonstrate the unstable Morse code sequences can recognize successful by the sliding fuzzy algorithm and translated into readable characters. The disabled can input Morse code with their eyes to operate the computer and household appliances, such as lamps, fans, TV. Therefore, this study provides a useful assistive tool for a user with the Motor Neuron Disease to communicate with the general public.**

Keywords: EOG, Morse code, Motor Neuron Disease, Amyotrophic Lateral Sclerosis, assistive tool

I. INTRODUCTION

With the progress of information era, there are many assistive tools developed for the disabled to interact with their environment. However, the Morse code is an efficient tool [10] for the severe disabilities such as the Motor Neuron Disease (MND) and the spinal cord injures. The Morse code is always used to represent various characters by a series of long-short tones. Now, there are many forms of switch to input Morse code, the user can select a fit and comfortable switch such as a single switch (the blow type and the bite type etc.) [11]. But a user must remember the miscellaneous Morse code and accept an exacting training on the stable typing speed with a fixed long-to-short ratio. To keep a fixed input speed that is difficult for the disabled people. In order to release the serious limitation of typing speed control, several algorithms were proposed to chase the typing pattern of a user. After 1995, there are several algorithms [1-9] proposed for unstable input speed by using adaptive and network signal processing techniques including adaptive unstable-speed prediction (AUSP)[1], least mean square and matching (LMS&M)[2], adaptive variable-ratio threshold prediction (AVRTP)[3, 4], the back propagation neural network (BPN)[5, 6], and fuzzy algorithms (e.g. fuzzy recognition [7, 8]). The recognition rate of unstable typing pattern had significant improvement from AUSP algorithm (29.1%), LMS&M algorithm (81.6%) to AVRTP algorithm (94.0%)[4]. It is successful to solve the problem of the irregular input speed, but the mathematic computation becomes more and more complex, except fuzzy algorithm can be installed in the single-chip microprocessor as real time recognition for a portable device.

This study purposes to provide an novel Morse code assistive input device for individuals with the Motor Neuron Disease, such as Amyotrophic Lateral Sclerosis (ALS), we named "EOG Single switch Morse code Translate input device (ESMcTin)". ESMcTin includes two parts that are EOG switch and Morse code automatic recognition algorithm. In EOG switch, ESMcTin measurements the Electro-Oculography (EOG) signal and translated into Morse code signal by the baseline tracing algorithm. In Morse code automatic recognition algorithm, we use fuzzy theory combining with the signal processing (ie. the sliding window average algorithm) to recognize Morse code and translated into readable characters. This recognition algorithm process its simple and fast–speed calculation is easily installed in the single-chip microprocessor as real time recognition, and the signal processing algorithm can modify the unstable Morse code sequences to more stable sequences for raising the recognition rate of Morse code. The user can input Morse code by their eyes moving through ESMcTin to operate the computer and household appliances, such as lamps, fans, TV. Therefore, this study can provide a useful assistive tool for a user with the Motor Neuron Disease to communicate with the general public.

II. METHOD

In this study, we divide ESMcTin into EOG single switch and Morse code automatic recognition algorithm. The structure of ESMcTin shown in Fig. 1.

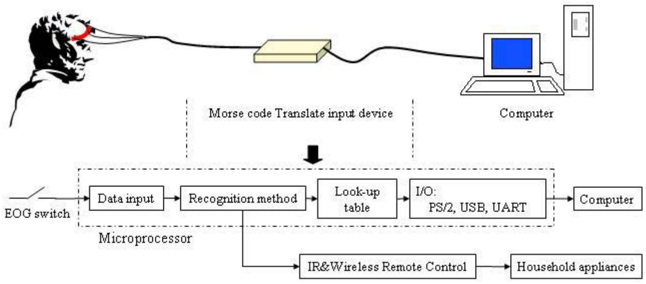

Fig. 1 The structure of ESMcTin

A. *EOG single switch combine with EOG baseline tracing algorithm*

This study design a novel EOG single switch to input Morse code for the lateral of ALS that the eyes can move autonomous only and the user can communicate with others by EOG switch. Due to the EOG signal is an unstable signal that the signal level is variable momentarily caused difficult to detect the eyes moment correctly. This study will translate the EOG signal into the standard logic level by baseline tracing algorithm, make a stable Morse code sequence, and the user can input Morse code easy by EOG switch.

EOG switch has two types in our study, one is a single switch that the user need control the eyes move to the same direction and according to the time of eyes' a round trip to input the long or short element of Morse code; the other is a double switch that the user can control the eyes move, when the eyes move to right is a short element of Morse code, whereas move to left is a long element of Morse code. In this paper, we illustrate the EOG Morse code single switch only , because of the user's eyes input Morse code by single direction can reduce eyestrain and uncomfortable from the eyes movement. But the user must practice the Morse code input more time to accomplish a stable and speedy output of Morse code.

In this study, the user controls the eyes move to right to input the long or short element of Morse code by the EOG single switch. When the eyes is in the static state (ie., the moving angle of the eyes is smaller than 15 degree), the device calculates the mean value (M) and standard deviation (S) of the EOG signal by sliding window average (Fig. 2) to avert the mistake action due to the user look the screen that the eyes moving. When the eyes is in the dynamic state (ie., the user input Morse code with the eyes), the signal is large than the critical level (M+3S), the device starts counting time; when the signal is smaller than the critical level (M+3S), the device stops counting time and this difference time as the Morse code input signal (I_k), and then to recognize the long or short element of Morse code by Morse code automatic recognition algorithm and translated into readable character. The structures of EOG single switch such as Fig. 2.

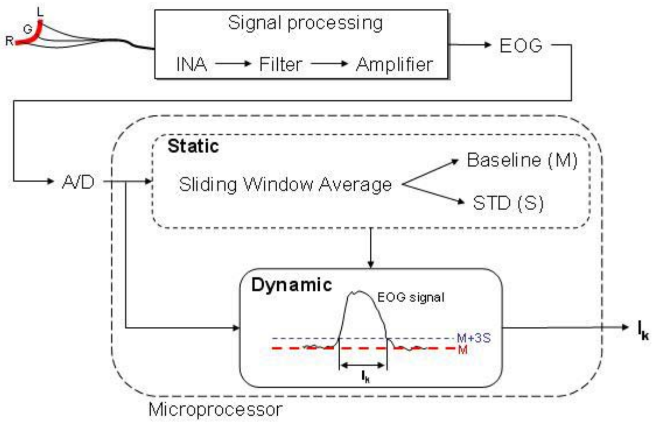

Fig. 2 The structure of EOG single switch

B. *Morse code automatic recognition algorithm*

The user cannot accurate control the long and short elements of Morse code when the user typing the Morse code with eyes for a long time, and the EOG Morse code signal is an unstable sequence. If want to recognize the significant character is more difficult. This study develops the sliding fuzzy recognition Algorithm (ie., the sliding window average and fuzzy recognition algorithm) to recognize the unstable EOG Morse code sequence.

In Fig. 3 where the I_k refers to original Morse code input signal from Fig. 2; the LSR refers to Long-to-Short Ratio (LSR) of Morse code input data, an output of the sliding window that the initial value is 3; the x_k refers to normalized Morse code input data; the e_k refers to the difference between input x_k and output y_{k-1}; the e'_k refers to the modified difference from e_k by a fuzzy algorithm; the y_k refers to predicted output and the T_k refers to threshold value to distinguish between long and short elements.

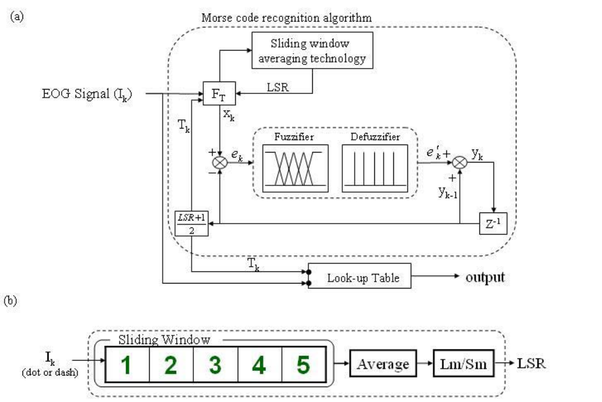

Fig. 3 The sliding fuzzy recognition system: (a) Morse code recognition block diagram; (b) The sliding window averaging technology

The block diagram of the sliding fuzzy recognition algorithm shown in Fig. 3(a) applies to chase the typing pattern's long-to-short ratio of a user and modify the threshold to distinguish between long and short elements.

The sliding fuzzy recognition procedure is described below:

1. To find the typing speed, the original input data I_k is normalized by function F_T,

$$F_T\begin{cases} x_k = I_k, & \text{if } I_k < T_k \\ x_k = \dfrac{1}{LSR} I_k, & \text{if } I_k \ge T_k \end{cases} \quad (1)$$

Where T_k is the kth threshold to distinguish between long and short elements.

2. To reduce the difficulty in maintaining a stable input rate and increase the stability of signal processing, the sliding window averaging technology is used to chase the variation of long-to-short ratio. The following adopts two windows which have five data (w_{lb}, w_{sb}) where lowercase 'l' and 's' refer to the sliding window of long and short elements respectively, and the lowercase 'b' is the position of input data put in the sliding window, and calculate the average of long and short elements (L_m, S_m) respectively,

When input data I_k is long element,

$$w_{lb}=w_{lb-1},\ lb=5,4,3,2 \quad (2)$$

$$w_{l1}=I_k \quad (3)$$

$$L_m=\frac{\sum_{k=1}^{5} w_{lk}}{5} \quad (4)$$

Otherwise,

$$w_{sb}=w_{sb-1},\ sb=5,4,3,2 \quad (5)$$

$$w_{s1}=I_k \quad (6)$$

$$S_m=\frac{\sum_{k=1}^{5} w_{sk}}{5} \quad (7)$$

Then

$$LSR=\frac{L_m}{S_m} \quad (8)$$

3. The prediction error e_k, an input to the fuzzy algorithm, is created by the difference between x_k and y_{k-1},

$$e_k=x_k-y_{k-1} \quad (9)$$

To obtain e'_k, a linguistic fuzzy rule is the same as shown in the one-node fuzzy recognition algorithm.

4. Based on the values of e'_k and y_{k-1}, the predictive output y_k and threshold T_k are updated by

$$y_k=y_{k-1}+e'_k \quad (10)$$

$$T_k=\frac{LSR+1}{2}\, y_{k-1} \quad (11)$$

By repeating steps 1~4, the system can automatically adjust the threshold value (T_k) in response to the typing speed variation and the varying ratio of long to short element. T_k is $\frac{LSR+1}{2}$ times of y_{k-1} (i.e., the middle value of between long and short elements). The look-up table in Fig. 3(a) is used to translate Morse codes into readable characters.

III. Result and Discussion

This section presents the test result of the EOG single switch and Morse code automatic recognition algorithm, and the clinical application.

A. The output of the EOG single switch

Fig. 4 is the output of the EOG single switch, Fig. 4(a) is the digital signal of the original EOG signal by ADC, and Fig. 4(b) is the output of EOG single switch by baseline tracing algorithm. When the user input Morse code by the eyes, the level of signal has the drift, but the baseline tracing algorithm can trace the baseline variation of EOG signal in the static state, such as Fig. 4(a) and output the correct Morse code signal such as Fig. 4(b).

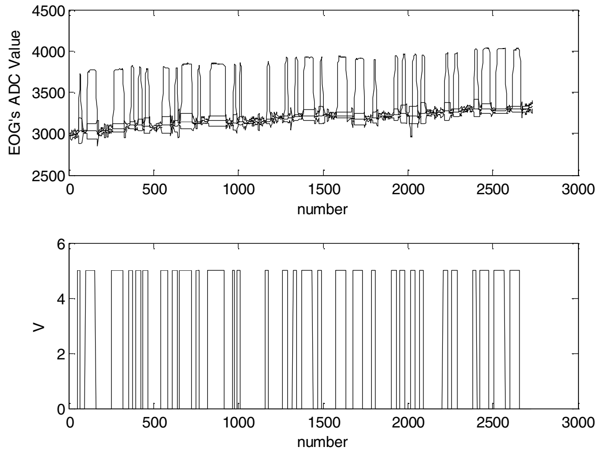

Fig. 4 The output signal of EOG single switch

B. The performance of Morse code recognition algorithm

We designed a simulation data to test the performance of Morse code recognition algorithm (i.e., the sliding fuzzy recognition algorithm). Simulation data is a Morse code sequence in an alphabetic order from a to z with a sinusoidal speed variation for the user's typing variation (fast or slow). In simulation of data that the long element is set at 300msec, the short element is set at 100msec, and the variation of sinusoidal is 100msec in the Morse code sequence (the variation of the long-to-short ratio is about from 3:1 to 2:1). Fig. 5 is the sliding fuzzy recognition result that can adjust the threshold value between long and short elements correction in quick motion and have a successful recognition for long-to-short ratio variation from 3:1 to 2:1.

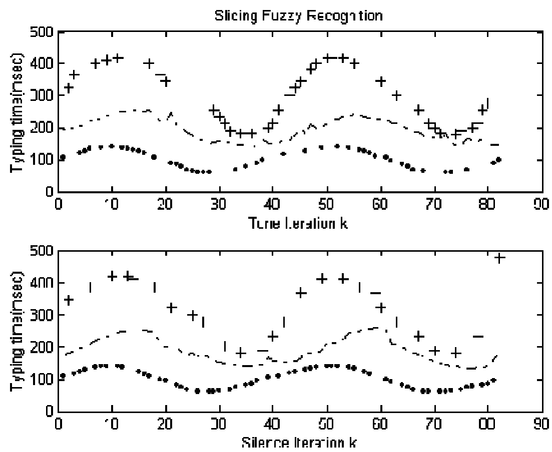

Fig. 5 Recognition result with simulation data by the sliding fuzzy algorithm

C. The clinical application

The user used the specially designed EOG single switch to input the appropriate Morse code elements for alphanumeric characters. The corresponding characters were then presented to him on a computer monitor in real time. This study presents the result of ten times typing test from two subjects that they are both beginner of Morse code. The subject's typing patterns and speeds when typing the ten letters (a to j) of the English alphabet were recorded, the average recognition rate about 98% and spends between 48 and 69 seconds.

IV. CONCLUSIONS

In this study, the unstable signal is transformed to standard logic level by EOG baseline tracing algorithm in the Microprocessor. And then the outputs unstable Morse code sequences are recognized by the sliding fuzzy recognition method. The results demonstrate the unstable Morse code sequences can be recognized successful by the sliding fuzzy algorithm and translated into readable characters.

In the clinical application, the user can input the character stable and correctly by EOG single switch, but the eyes will get tired easily by typing the code with eyes for a long time and making the unstable Morse code sequence. How to improve this defects that is an important subject in future.

Additionally, we will alter the functions of the ESMcTin and enhanced the training of Morse code input depends on the comments of the user. Hope the ESMcTin is a useful assistive communication tool can help the servers disable to communication with others.

ACKNOWLEDGMENT

The National Science Council, Taiwan, Republic of China supported this research, under contract NSC94-2213-E-168-018.

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