

Implementation of Fuzzy Decision to Control Patient Room Facilities using Eye Blink

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Abstract. This study proposed the implementation of Fuzzy decision to control patient's room facilities. In this study, four icons were sequentially displayed on the computer screen. The icons representing four option that can be selected by the patient is including switch the light on/off, switch the fan on/off, moving the bed's backrest downward, and moving the bed's backrest upward. The eye blink was extracted from subject's electroencephalograph (EEG) signals which acquired from the FP1 region. The attention was also extracted from subject's EEG signals to ensure that subject concentrate to the task. The eye blink and attention level were used for Fuzzy decision inputs, while the output is a decision that states the selection is valid or not. The selected option is the command that appears on the screen when the selection is valid. In this study, subjects were asked to choose each command several times and the accuracy was computed based on the number of correct selection.

1. Introduction

Some people cannot perform some daily activities including walking, grasping etc. because of some condition such as Amyotrophic Lateral Sclerosis (ALS) diseases. ALS is defined as diseases that attach body muscle which cause the subject cannot conduct any voluntary movement [1], [2]. In some cases, the patient cannot perform any activities and only lying on the bed. Because of the condition, these people need some assistive device to help them conducting some daily activities.

Some researcher uses the subject brain signal as an input to control some assistive device. The technology that utilizes subject electroencephalograph (EEG) signal to control some device is defined as Brain-computer interface (BCI) devices [3]. Some gaming devices have been developed by using brain signal to control game object movement such as air swimmers [4]. BCI-based feeding robotic has been developed using arm robot controlled by brain signal [5], [6]. BCI-based wheelchair has been designed to assist patients to move from one to another place [7], [8].

In the ALS diseases, the eye muscle still retains its function while the other voluntary muscle has been paralyzed [9]. Because of this condition, the motion generated by eye muscle such as eye blinking can be used as input to control assistive device for ALS patients. There are several researches that used eye blinking signal as input to control some devices such as text typing systems [10], [11], and home lighting equipment [12]. The eye blinking can be detected from the EEG signal by filtering the signal with frequency less than 5 Hz and the amplitude is greater than 4 μ V [12]. The Fp1 channel can be set as the location to acquire EEG signal and obtain the eye blink signal [13].

The ALS patient usually spent their time by staying in their room and lying on the bed. Sometimes they want to move their bed backrest upward or downward, switch the light on/off, and switch the fan on/off to make them feel comfortable. Based on the description, a system is developed to provide patient room facilities that can be controlled by subject eye blinking gestures. The room equipment



that can be controlled including switch the light on/off, switch the fan on/off, moving the bed's backrest downward, and moving the bed's backrest upward.

2. Experimental Details

2.1. System Design

In this system, a computer screen was placed in front of the subject to display four icons representing the control command. The control command that is provided is including switch the light on/off, switch the fan on/off, moving the bed's backrest downward, and moving the bed's backrest upward. Only one icon appeared on the computer screen, while the other icons were hidden. Each icon appears in the computer screen for the same period. The sequence of icons that displayed on the computer screen is shown in Figure 1. The command can be selected by blinking the subject eye when the suitable icon is displayed on the computer screen. The subject should also keep his/her attention at a specific level in order to obtain a valid selection.

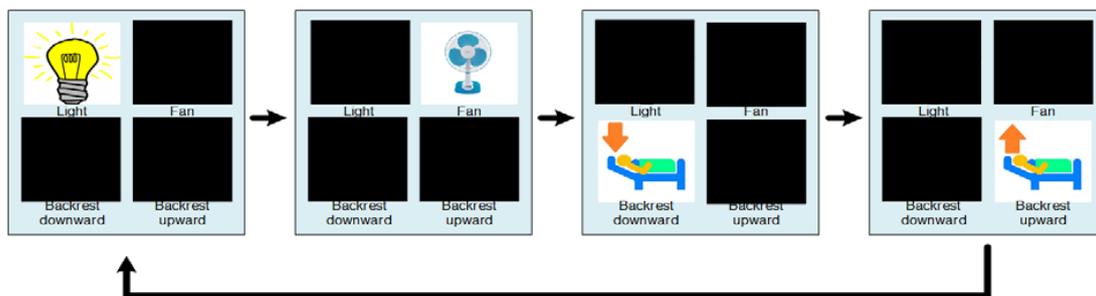


Figure 1. The sequence of icons that displayed on the computer screen

During the experiment is conducted, the subject EEG signals were acquired. The EEG acquisition is conducted using Mindwave Mobile headset from Neurosky Company. The electrode was placed at FP1 channel while the ground and reference are located at the left earlobe. The raw EEG signal is sampled at 512 samples/second. The raw EEG signal is digitized using 10-bit analog to digital converter by ThinkGear ASIC Module (TGAM) in the headset. The digitized raw EEG signal is sent through Bluetooth communication to the personal computer (PC) and used to detect the blink strength.

The eye blink strength was obtained from raw EEG signal after several processing steps. Because the eye blink has low frequency, the raw EEG signal is filtered using fourth order Butterworth low pass filter. The filter's cut off frequency is set to 5 Hz. Based on the filtered EEG signal, the maximum value in one time frame was computed. The maximum value is used as the eye blink strength. The attention level was also measured and sent to the PC for further analysis. The attention level is used to ensure that the subject is focus on the task. If the attention level is higher, it is mean that the subject more focuses on the task. When the subject is rest, the attention level will be low.

The blink strength and attention level are used as Fuzzy input, which the Fuzzy output is decision expressing that the selection has been made or not. When the selection has been made based on the Fuzzy output, the selected option is the icon that appears on the computer screen. The decision of the selected option is used to control the room facilities. The overall system design is shown in Figure 2.

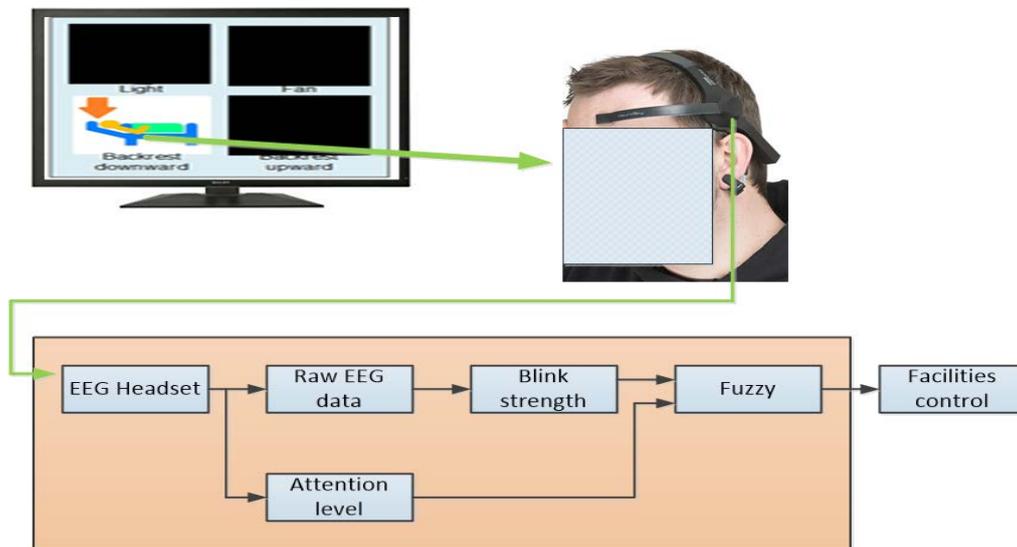


Figure 2. System Design

2.2. Fuzzy Decision Model

Fuzzy inference was used as decision model in this study. The structure of the Fuzzy decision model is shown as part of the system in Figure 2. The blink strength (BS) and attention level (AT) were used as fuzzy inputs. The attention and blink strength value are normalized into range 0 to 100 before used as fuzzy inputs. The fuzzy input sets are divided into 5 linguistic value, including very low (VL), low (L), normal (N), high (H), and very high (VH) for both inputs. While the fuzzy output sets are defined into 5 linguistic value, including very not valid (VNV), not valid (NV), normal (N), valid (V), and very valid (VV). The membership function of the fuzzy that used in this study is shown in Figure 3.

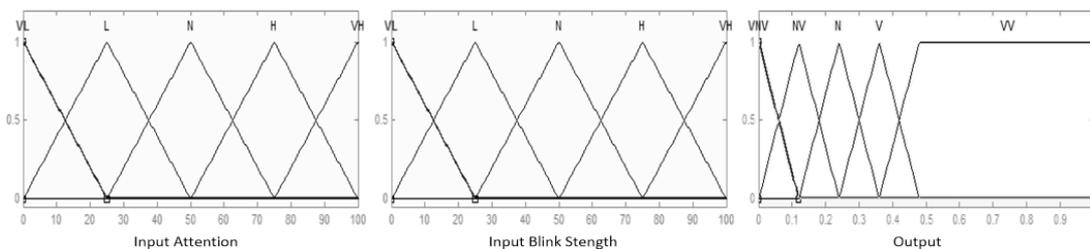


Figure 3. Fuzzy Membership

The inference rule that is used in this study is defined as

$$\text{if AT is } A_i \text{ and BS is } B_j, \text{ then } y \text{ is } C_{ij}, \tag{1}$$

where i and j are the indexes of rules. A_i and B_j are the membership functions of attention (AT) and blink strength (BS), respectively. C_{ij} is the fuzzy decision output based on the rules that shown in Table 1.

Table 1. The rules of the fuzzy decision

$A_i \backslash B_j$	VL	L	N	H	VH
VL	VNV	VNV	NV	N	N
L	VNV	NV	NV	N	N

N	NV	NV	N	N	V
H	N	N	N	V	VV
VH	N	N	V	VV	VV

The fuzzy decision output variable, F'D is the result of the defuzzification process and computed using center of gravity, as

$$F'D = \frac{\sum_{i=1}^n S_i B_i}{\sum_{i=1}^n S_i} \quad (2)$$

where the variable S_i is the grade of the fuzzy membership of the i -th premise based on the inference rule, and variable B_i represents the center value of the i -th conclusion.

The decision output (FD) is computed by rounding the fuzzy output variable (F'D) up. The decision output can be defined as:

$$FD = \text{round}(F'D) \quad (3)$$

If the decision output (FD) is 1, then it can be concluded that the selection is valid and the selected command is the command that appears on the screen when the decision is made.

3. Results and Discussion

The experiment was conducted by asking the subject to sit in front of computer monitor. The subject is asked to use NeuroskyMindwave. The subject brain wave signals were acquired and recorded from Fp1 channel using NeuroskyMindwave. The acquired EEG signal is processed and analyzed to obtain the decision. Based on the decision, the command selection is made by choosing the icon that appears when the decision is made.

The first experiment is conducted by changing the time interval between icons to appear on the computer screen. Several time intervals were used in this experiment, including 1, 2, and 3 seconds. In this experiment, subject was asked to make 20 correct selection. Based on the number of correct and wrong selection, the accuracy was computed. The experiment result is shown in Table 2.

Table 2. The Experiment Result using different time interval

Subject	Time interval		
	1 second	2 second	3 second
A	83%	87%	91%
B	83%	91%	91%
C	80%	83%	83%

The experiment result is shown that time interval 1 second yields the worst result. The subjects said that the time interval 1 second is not enough for them to make a decision and choose the command by blinking their eye. Sometimes when they make the decision and choose the command, the icon has changed and yielded a wrong selection. The time interval 3 seconds yields the best result, while time interval 2 seconds yields the result that almost same as time interval 3 seconds. Because time interval 2 seconds give the result that almost same as the best result, therefore the time interval 2 seconds is used in the next step. The time interval 3 seconds is not used in next step because it will take time to wait the option changed from one icon to another icon.

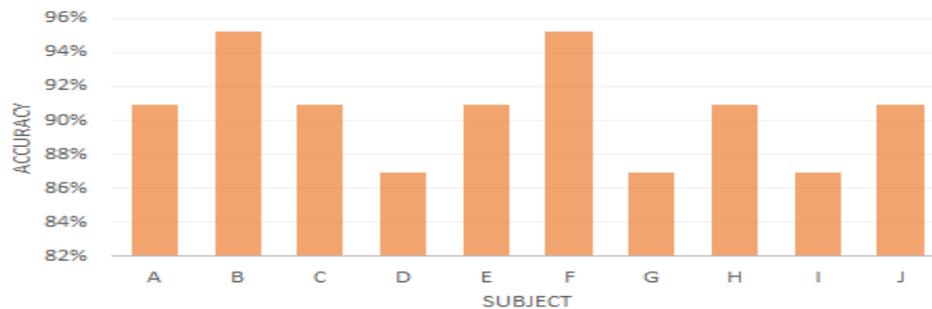


Figure 4. Experiment Result

The second experiment is conducted by asking 10 subjects to participate in the experiment. This experiment is conducted to test the performance of the proposed approach using time interval 2 seconds. In this experiment, subject is asked choose every option for 5 times, therefore the subject should make 20 correct selections to finish the experiment. Based on the number of correct and wrong selection, the accuracy was computed. The experiment result is shown in Figure 4. The result shows that the average accuracy was 90.59%, while the maximum and minimum accuracy is 95.24% and 86.96%, respectively.

4. Conclusion

All subjects in this experiment yield the accuracy more than 80%, so the accuracy of the proposed approach is high enough. Therefore, the proposed approach can be implemented as decision model to provide patient's room facilities control using eye blink. Using the eye blink and attention level as input of Fuzzy system, the system can be used to select the command to switch the light on/off, switch the fan on/off, moving the bed's backrest downward, and moving the bed's backrest upward.

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