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The influence of beta signal toward emotion classification for facial expression control through EEG sensors

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Abstract

The important role of communication process between human and computer have been increased in the recent years. In this paper, the main focus on analyzing human brain signals to create a natural interaction between human brain and virtual human. The method of this study base on reading brain signals then classifies the signals in order to represent it as an avatar facial expression. These signals are associated with the inner emotion of the user. In order to get a real interaction between the internal emotion of a user and avatar facial expression, signal speed is used to clarify the difference of user situation for two emotions: happy and sad. The interactive process based on the relationship between human emotion and the velocity of brain signal from the result ΔV for Z1 is faster than ΔV for Z2. In this case, the velocity of sad emotion will be faster than happy emotion. As a result, this study shows a range of speed for each emotion which can be used to specify and represent the internal emotion of a user to create a natural interaction with virtual human. These results can be more realistic because it specifies the average of speed for each emotion.

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Keywords: Brain signal; Beta signal; Avatar; Facial expression;

1. Introduction

In the recent years, the significant role of interaction between human and computer have been increased. Brain computer interface (BCI) describes a direct interaction process between human brain and computer. Electroencephalogram(EEG) is used to measure brain activities and the relationship between human brain signals and human emotion. BCI system determines the intent of the user from different brain signals.These signals translate real-time into commands that implement in a computer. EEG is widely used because it's easy to control and implement from other methods which used to explain brain signal functions. BCI system based on EEG to change the electrophysiological of user brain into commands to be represented in computer applications. In the last few years, several studies explained the important role of BCI systems toward human emotion. BCI system can be divided into two main functions, The first one is to measure some properties of brain activities while the second one is to translate these properties into control signals as an output [1]. Different algorithms used for analyzing EEG

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signals, One of these algorithms is adaptive nearing- fuzzy interface system (ANFIS). It used to classify EEG signals based on continuous wavelet transform by extract brain signal features [2]. Other studies used time to calculate the frequency base on extract statistical features of EEG signals to classify user emotion [3]. After the growth by using a human computer interface (HCI) in different fields [4]. Facial animation became a challenging problem because the human face consists of many parts and a lot of details. The first attempt to generate facial animation was by [5]. After that many attempts tried to generate realistic facial animation because of facial parts is not easy to control and manipulate. Facial animation is very necessary in our daily life and in different fields like, medicine, psychology and computer graphics. It is the first step to generate facial expression of 3D virtual human which use to represent human emotions. Many researches focused on generating facial expression of virtual human in 3D environment. The essential aim was to create interaction between human and virtual human without paying attention to represent internal emotion of user as an avatar facial expression. This research attempts to provide a natural emotional interaction control between user and virtual human by reading the brain signal, classify, interpret and transfer it to virtual human.

2. Method

There are various steps that can be used to achieve the scope of this research. Figure 1 is to explain system architecture with all steps and more details. In the beginning, the inputs will be extracted based on using a particular sensor device which is called NIA (neural impulse actuator). NIA has three electrodes that use to read brain signal activities. In order to generate avatar with facial expression control, this research relies on the facial action coding system (FACS) as a system to explain avatar facial expression behavior. It divides the face into many regions which called action units (AU). The action units rely on facial muscle movement to generate facial expressions. Facial expression can be generated by combining each action unit to perform a particular facial expression [6]. In this research, time frequency domain used to get brain signal speed for each happy and sad emotion, therefore time, wavelength, velocity need to be calculated. The distance of the wave can be obtained in terms of its wavelength (λ). The wavelength can be measured from any point to the identical point on the next wave. Signal speed can be calculated based on velocity as shown in the next equations:

$$\text{Velocity } (\Delta V) = (\lambda) / \Delta (T) \quad (1)$$

Time is the first step to calculate velocity for each emotion. ΔT represents the difference in time between the second hit with first hit and third with a second hit for the frequency changing in a particular time for each emotion and so on. As shown in the Next equation:

$$\Delta (T1) = \Delta (T1) - \Delta (T0), \Delta (T2) = \Delta (T2) - \Delta (T1) \quad (2)$$

Δ T represents different in time of frequency changing. After getting $\Delta(T)$ velocity needs to calculate based on the next equation:

$$\text{Velocity } (\Delta V) = \text{distance} / \Delta (T) \quad (3)$$

Distance represents the signal wavelength.

3. Result and Implementation.

The description of data collection and data analysis are very necessary to understand the final result. Data collection, data analysis and implementation are showing the effect of beta signal toward emotion classification of facial expression control through EEG sensor device. In this research, Data collection process will be explained and how data are collected in order to get Δ T then how Δ T used to calculate Δ V in order to specify signal speed of user brain waves. After data collection, data analysis will be clarified based on the previous equations of Δ T and Δ V, The implementation of the result will be represented in tables and graphs. These tables describe the velocity change of sad and happy emotion among same time. The average of Δ V shows the difference of signal speed.

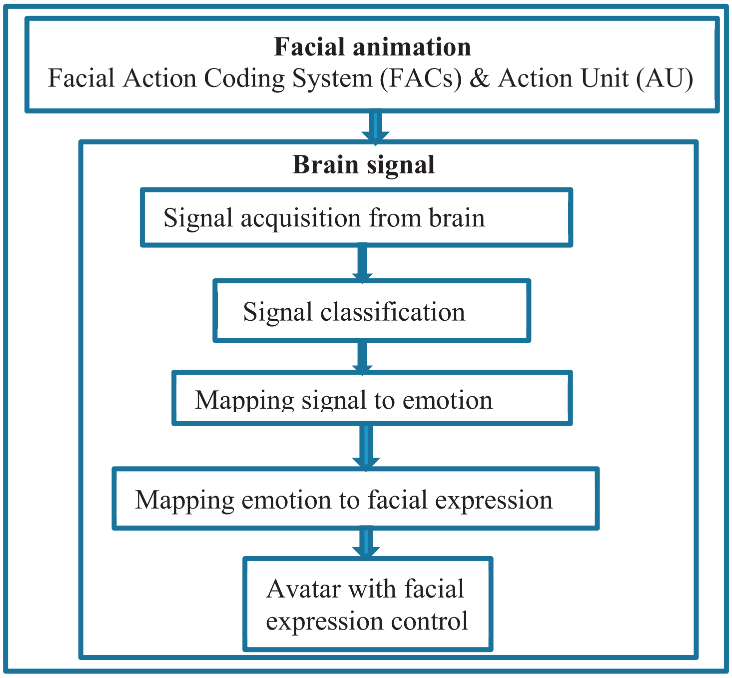

Fig. 1. System architecture

3.1. Data Collection

In this research, data collection is the process of information gathering about results and other operations that help to generate these results. The scope of this study is to create realistic contact between user inner emotion and 3D virtual character. Data collection includes particular steps to achieve the target of this study. The system depends on video recording to capture the brain signal based on the internal situation of user at a specific time. There are five main zones represent the area of signal movement as shown in Figure 2. Signal speed can be recorded during 4 second and based on video recording to see the number of hits for each zone of Z1 and Z2 during that time. User can make this test for many times and in different situations. The two main elements to get signal speed are Δ T and distance. Δ T relies on the difference of frequency changing which can be represented by the number of hits in each zone during specific times (The pointer of signal movement used to record number of hits in each zone and during interaction process). On the other hand, the distance depends on the size of each zone.

Among the recording process, the result which represents the number of hits for each zone will be shown during a particular time. Number of hits represent the frequency changing of signals in milliseconds. As shown in Table 1.

Table 1. Explain ΔT calculation.

Number of hits	Hour	Minute	Second	Millisecond
First hit	11	47	7	820
Second hit	11	47	7	837

In the previous table, the first hit of Z2 was at this time 11:47:07 AM; 820 millisecond and the second hit of Z2 was at this time 11:47:07 AM; 837 millisecond. 820 MS represents ΔT0 while 837 MS represents ΔT1.the calculation of Δ (T1) = 837-830= 17 milliseconds and the same rule for other values. The calculation of Δ (V) based on getting Δ T from previous process in addition to distance.

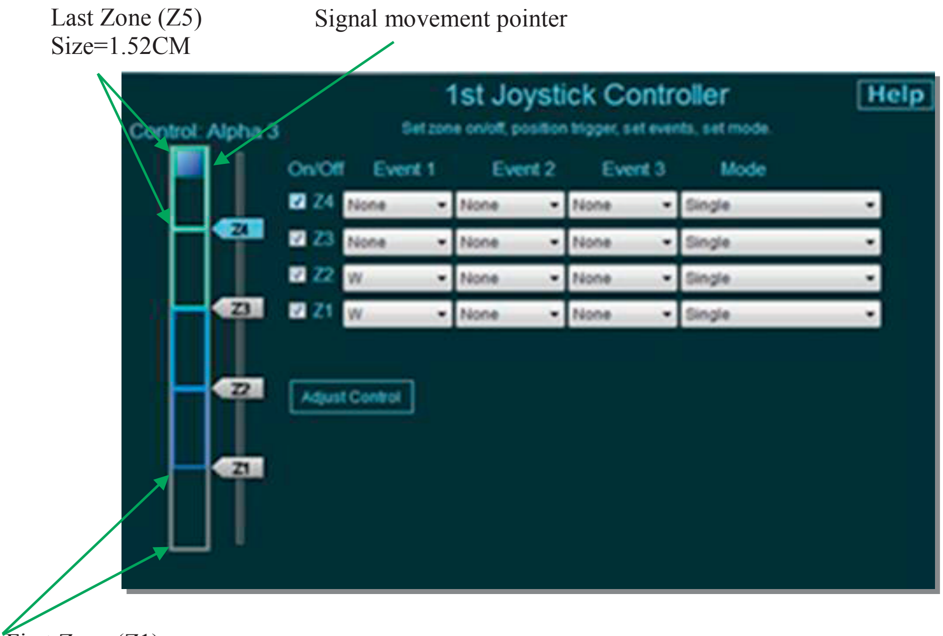

Fig. 2. Classification of alpha and beta zones

3.2. Data Analysis and Implementation

Velocity relies on the number of hits in each zone during particular time. Z1 are associated with sad emotion and Z2 are associated with happy emotion because the difference between them in the emotional strength [7]. Each zone of Z1 and Z2 can be divided into other five zones to get the distance as shown in Figure 2. The total size of each zone is 1.52 cm. NIA represents brain waves of alpha and beta signals in 20 bars. By dividing 20/5, the result is 4 bars for each zone. After that 1.52cm/4= 3.8cm which represent distance. The final result of beta signals calculates by using Equation:

$$\Delta V = 3.8\text{cm}/\Delta T \text{ millisecond} \quad (4)$$

The implementation of beta signals shows ΔV of beta1 and beta3 during a specific time and it consists of two tables and four graphs. The tables calculate ΔV of beta1 in Z1 and Z2 and ΔV of beta3 in Z1 and Z2 with the average of each one. Beta signal tables explain ΔV1 to ΔV9 values which measured by cm/millisecond. Table 2 clarifies the change of signal speed of beta1, beta3 in Z2 zone which associated with happy emotion while table 3 clarifies the change of signal speed of beta1, beta3 in Z1 zone which associated with sad emotion. As shown in Table 2 and Table3.

Table 2. Calculate (Δ V) of beta1 and beta3 in Z2 zone.

Z2	Δ (V1)	Δ (V2)	Δ(V3)	(ΔV4)	Δ(V5)	Δ(V6)	Δ(V7)	Δ(V8)	Δ(V9)	AverageΔ(V)
Beta1	0.02	0.001	0.25	0.021	0.023	0.022	0.023	0.07	0.025	0.392 Cm/Ms
Beta2	0.015	0.05	0.01	0.004	0.022	5.98	0.022	0.03	0.003	6.129 Cm/Ms

Table 3. Calculate Δ (V) of beta1 and beta3 in Z1 zone.

Z1	Δ (V1)	Δ (V2)	Δ(V3)	(ΔV4)	Δ(V5)	Δ(V6)	Δ(V7)	Δ(V8)	Δ(V9)	AverageΔ(V)
Beta1	0.022	0.38	0.38	0.13	0	0.023	0.022	0.022	0.022	1.001 Cm/Ms
Beta3	0.02	0.012	0.022	0.022	0.011	8.86	0.004	0.022	0.022	8.995 Cm/Ms

From Table 3, the average of ΔV for beta1 from ΔV1 to ΔV9 is 1.001 and the average of ΔV for beta3 is 8.995 during the same time while in table2 the average of ΔV for beta1 from ΔV1 to ΔV9 is 0.392 and the average of ΔV for beta3 is 6.129 during the same time. As a conclusion of previous values, signal speed of sad emotion is faster and more stable than signal speed of happy emotion because of the average values in Z1 which associated with sad emotion of a user is more than the average values of Z2 zone which associated with happy emotion. In the next figures, the graph representation of ΔV values of beta1 and beta3 signals in Z1 and Z2 zones which associated with sad and happy emotions.

4. Discussion

BCI sensor devices like the NIA and other sensor devices can be used as a new input device instead of the common input devices like keyboard and mouse. NIA based on EEG so it is suitable for reading and classifying the signals. The advantage of this device is the low price comparing with other devices. The study is to find a way to measure the speed of brain signal depends on the number of hits for each emotion. Δ (T1) = T1-T0 is to measure the difference in time between the second and the first hit in milliseconds and also can be applied to other values during the interaction process. After getting ΔT, the values of ΔV can be calculated by applying (Speed= distance/ Δ (T)). In this study, the average of ΔV values of beta1 and beta3 in Z1 zone is compared with the average of ΔV values of beta1 and beta3 in the Z2 zone during the same time of interaction. The comparison achieved the target of this study by proving that sad emotion speed is more than happy emotion speed because of the difference between them in the emotional strength based on arousal and valence 2D space [7]. The last results can be used to create a new product. This product can be applied in different applications in our life. For example is it possible to be as a laying detector.

5. Conclusion

This paper analyzes signal speed as a new method to generate effective communication between user and virtual human. The methodology combines two main phases. First, generate facial expression Then classify user brain signals depend on particular methods and the last phase is combining the previous phases together to create more realistic interaction. Furthermore, the speed of the signal determines the internal situation of user compare with his facial expression. This study proved that sad emotions faster and more stable than happy emotion because the number of ΔV in Z1 zone which represent sad emotion is more than ΔV in Z2 zone which represent happy emotion. During the interaction process, we will be able to recognize if user telling truth or not because the main concentrate on the inner emotion not only on facial expression.

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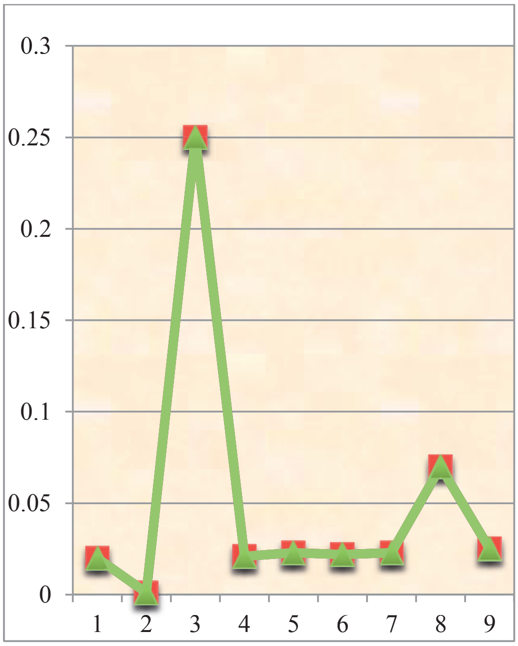

Fig. 3. ΔV values of beta1 in Z2

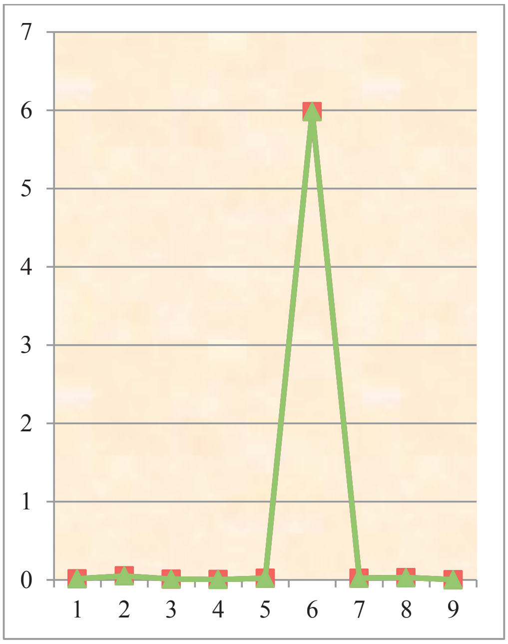

Fig.4. ΔV values of beta3 in Z2

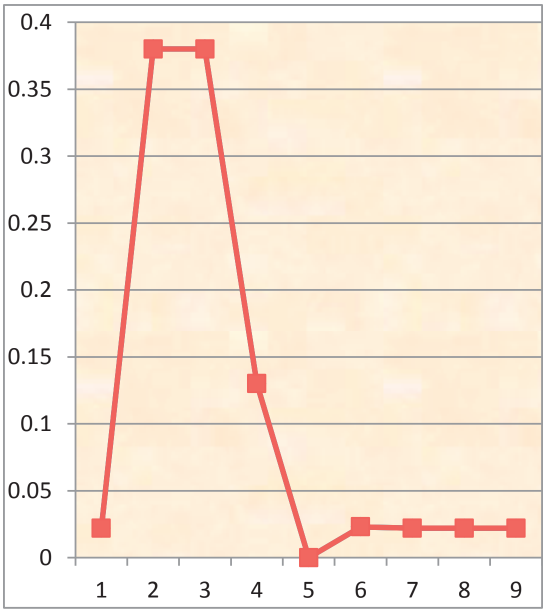

Fig. 5. ΔV values of beta1 in Z1

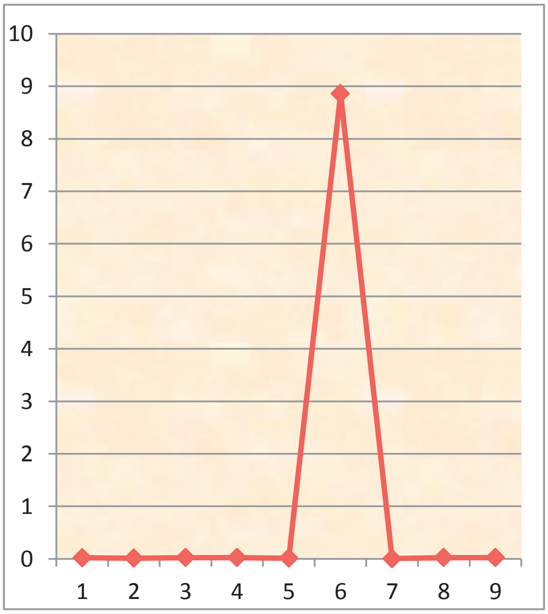

Fig . 6. ΔV values of beta3in Z1

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