FUZZY MODELING AND CLASSIFICATION OF TWO HUMAN HANDS EMG SIGNALS

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Abstract

Fuzzy logic and reasoning were applied to modeling and noise reduction of EMG signals measured from a person's two hands. An OLIMEX 328 microcontroller and two EMG shields were used to measure the EMG signals. A new classification and noise reduction method was presented.

Keywords: EMG signals, Fuzzy modeling, Human hand signal.

1. Introduction:

The main purpose of this paper is to present fuzzy modeling, noise elimination, and classification of EMG signals.

The aim of using the EMG signals measured from the left hand (LH) and the right hand (RH) of a person is to simplify the classification and noise reduction of the EMG signals. The human hand is a complex system with a large number of degrees of freedom (DOFs) [1]. For that, the classification of the EMG signal is quite complicated [2]. The attribute of the EMG signal depends on the subject's internal structure, including the individual skin formation, blood flow velocity, measured skin temperatures, tissue structure (muscle, fat, etc.…), the measuring site, and more [3]. The attributes produce different types of noise signals that can be found within the EMG signals [4].

A fuzzy logic system gives advantages in biomedical signal processing and classification because the biomedical signals are not always strictly repeatable, and may sometimes even be contradictory [5], one of the most useful properties of the fuzzy logic system is that contradictions in the data can be tolerated, furthermore, using the trainable fuzzy system, it is possible to discover patterns in data which are not easily detected by other methods. [6]

2. EMG's Signal Measurement:

The EMG signals for the research are measured from the left and right hands of a person (LH, RH) The EMG records are different from one hand to another according to the reasons mentioned before[3], for the same laboratory environments the two

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EMG signals will have the same noise effect, for that first EMG was considered as a main signal and the second as a reference, and by (XOR) the resultants from the ADC converter, the equal values will be canceled which represents the noise and the different values will be added which represents the result of adding the RH and LH EMG signals, same muscle activities must take in consideration.

EMG measures the electrical currents that are generated in a muscle during its contraction and represents neuromuscular activities. On the other hand, one of the main difficulties in analyzing the EMG signal is due to its noisy characteristics.[7]

If myoelectric control is selected as the primary control scheme, site identification must consider EMG signal level, EMG separation, and skin condition, marking the area on the skin surface that has acceptable EMG signal strength and separation and then donning the interface and transferring the site provides the best results.[8]

3. Fuzzy modeling of EMG signals:

Let the fuzzy implication R is of the format

R : IF (X_1 is A_1 ,...., X_k is A_k) then: y= g(x_1,-----, X_k) (1)

Where:

y: Variable of the consequence whose value is inferred.

X_1-----X_k: variable of the premises that appear also in the part of the consequences.

A_1---A_k: fuzzy sets with linear membership functions representing a fuzzy subspace in which the implication R can be applied for reasoning.

f: Logical function connects the propositions in the premise.

g: Function that implies the value of y when x_1----x_k satisfies the premise.[9]

If we have R^i implications of the above format:

R^i (i =1,......., n)

($x_1 = x_1^o$,--------,$x_1 = x_k^o$)

Where x_1^o,--------x_k^o are singletons, the value of y is inferred in the following steps

1) For each implication R^i, y^i is calculated by the function g^i in the consequence

$y^i = g^i(x^o_1,.... X^o{}_k)$

$= p^i + p^i{}_1 x^o{}_1 ,......+ p^i{}_k x^o{}_k$ (2)

2) The truth value of the proposition $y=y^i$ is calculated by the equation

$Iy=y^iI = (A^i{}_1(x^o{}_1) \wedge .... \wedge A^i{}_k(x^o{}_k)) \wedge I R^i I$ (3)

$I R^i I = 1$

So, the truth value of the consequences obtained is

$Iy=y^iI = A^i{}_1(x^o{}_1) \wedge .... \wedge A^i{}_k(x^o{}_k)$ (4)

3) The final output y inferred from n implications is given as the average of all y^i wit the weights $Iy=y^iI$: [10]

$$y=[\sum Iy=y^iI*y^i] \backslash \sum Iy=y^iI \quad (5)$$

Applying equation (5) for both EMG signals the LH and RH :

$$B1=[\sum IRH=RH^iI*y^i] \backslash \sum IRH=RH^iI \quad (6)$$

$$B2=[\sum ILH=LH^iI*y^i] \backslash \sum ILH=LH^iI \quad (7)$$

And by using Wilson amplitude (W_{amp}) which is the number of times that the difference between EMG signal amplitude among two adjacent segments exceeds a predefined threshold [11].

Applying Wilson amplitude for B1 and B2 we get:

$$C1_{Wamp} = \sum^{N}_{k=1} f(IB1_k= B1_{k+1} I) \quad (8)$$

$$C2_{Wamp} = \sum^{N}_{k=1} f(IB2_k= B2_{k+1} I) \quad (9)$$

Converting $C1_{Wamp}$ and $C2_{Wamp}$ to digital form (D1, D2) and XOR them the output y will be:

$$y=D1+D2 \quad (10)$$

the block diagram of the fuzzy modeling used in this research is shown in fig. (1). Where the RH and LH EMG signals were fuzzified then after a suitable consequence has verified a defuzzification was applied to A1 and A2 to get B1 and B2, then calculating W_{amp} for B1 and B2, as a result, we get C1 and C2, they both converted to digital form to have D1 and D2 as an input to the XOR gate in which the similar quantities were rejected(noise canceling), the output y will be in digital form if we need it as an analog signal a DAC can be used.

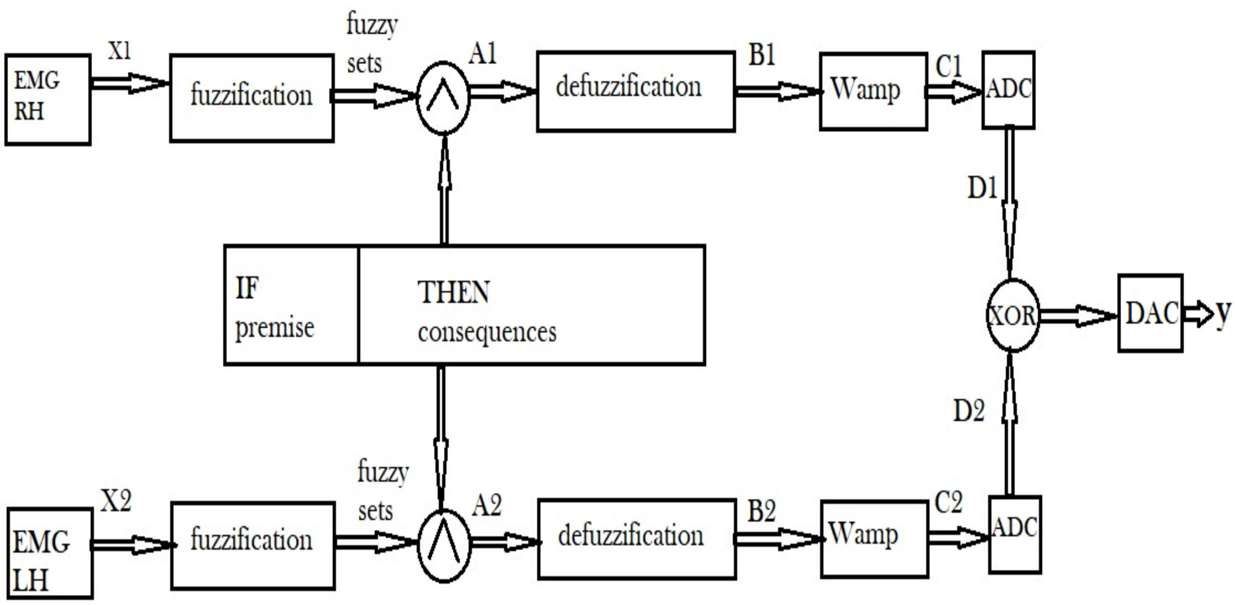

Fig. (1) Block diagram of measuring and fuzzy modeling of RH, LH EMG signals.

4. Experimental Results:

To measure the EMG signals of the right hand (RH) and the left hand (LH) of a volunteer in this research, a measuring system was built as shown in fig. (2).

Fig. (2) measuring system for EMG signals of the LH &RH.

An OLIMEX 328 microcontroller [12] used with two EMG shields was connected through a USB port of a computer and the measuring process was done by using BrainBay software [13], the complete design used in this research is shown in fig. (3).

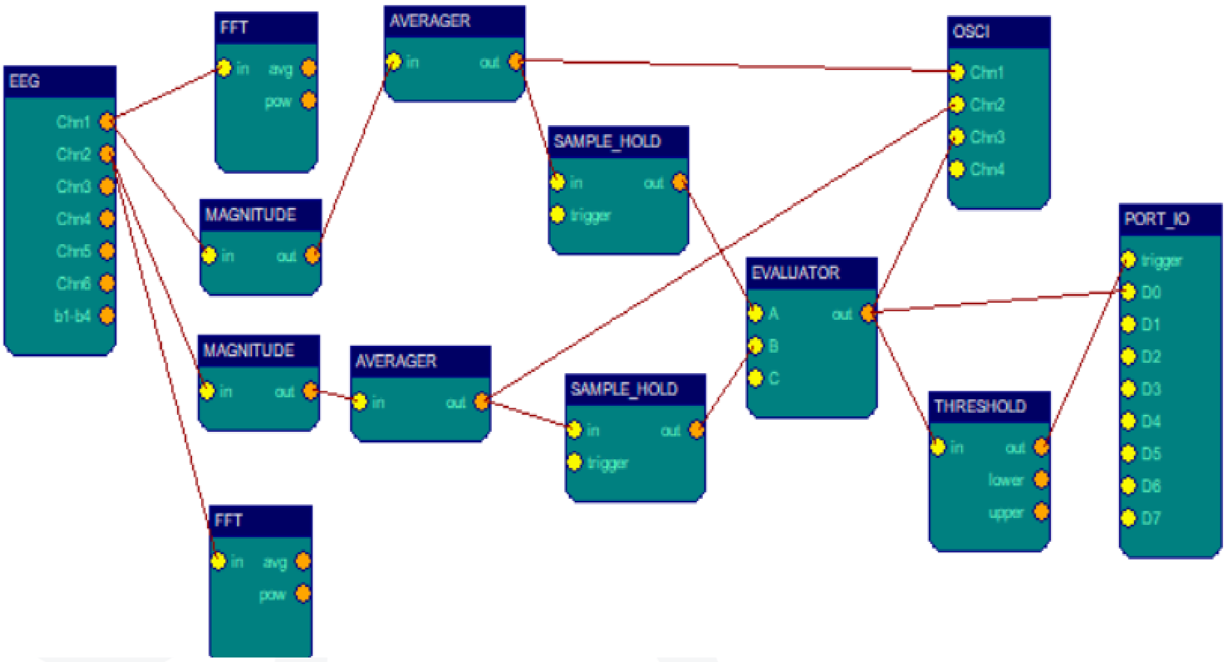

Fig. (3) measuring system design using BrainBay software.

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The raw measured and filtered EMG signals of the RH and LH are shown in fig. (4).

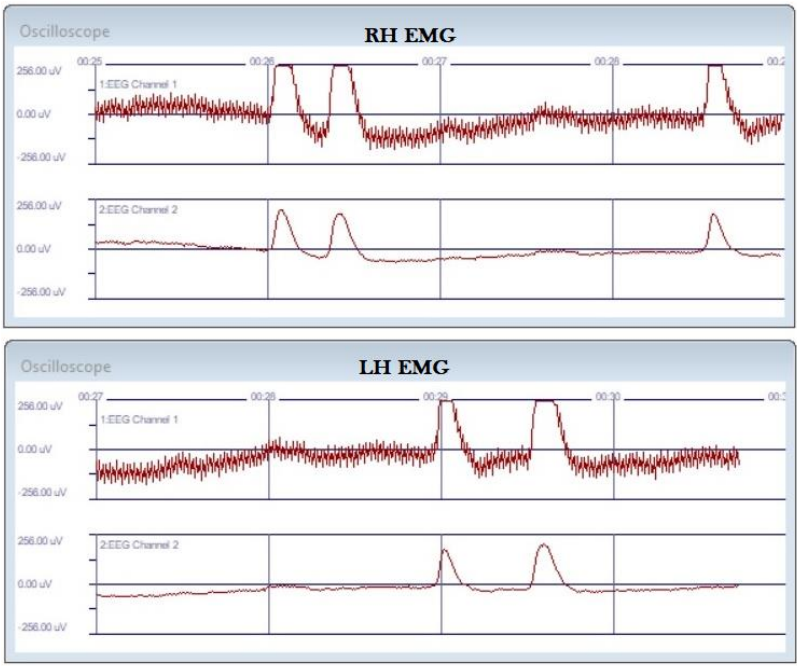

Fig. (4) Raw and filtered EMG signals.

To discriminate the noise of both EMG signals an FFT spectrum analyzer was used, fig. (5) shows the spectrum analyzer output.

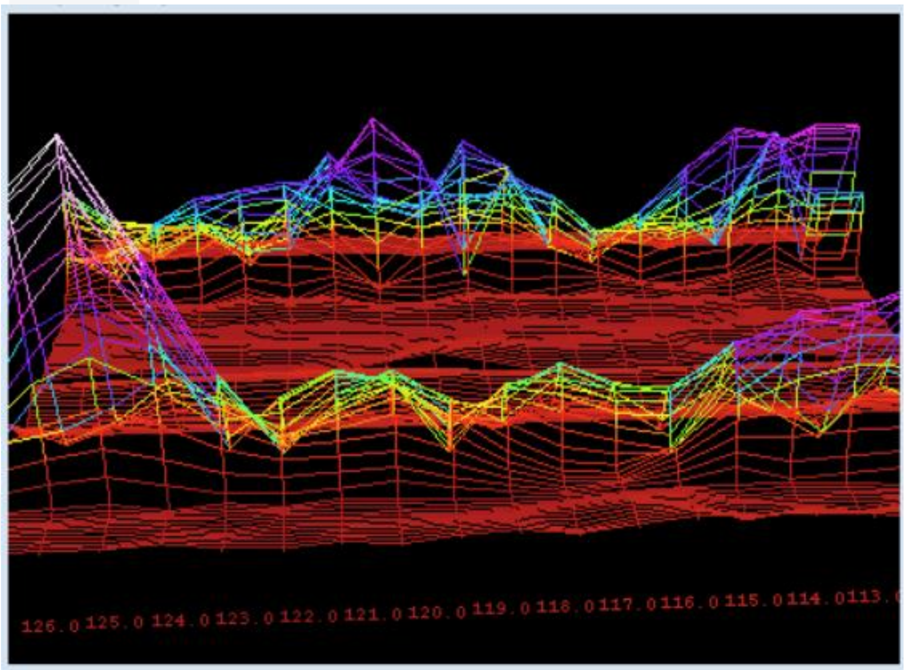

Fig. (5) spectrum analyzer output of LH and RH EMG signals

The filtered signals were processed using the Wilson amplitude method [6], fig. (6) shows the resultant EMG signals, from this result the researcher decides the type of filter used and the frequencies which must be filtered.

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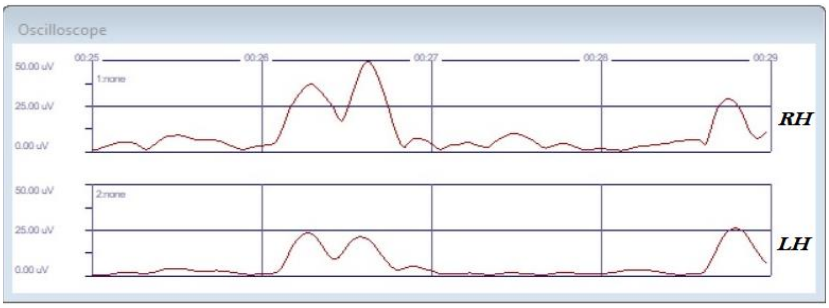

Fig. (6) EMG signals after applying the W_{amp} procedure.

The signals above (in fig. 6) passed through a sample and hold process, the result of the sample and hold is shown in fig. (7).

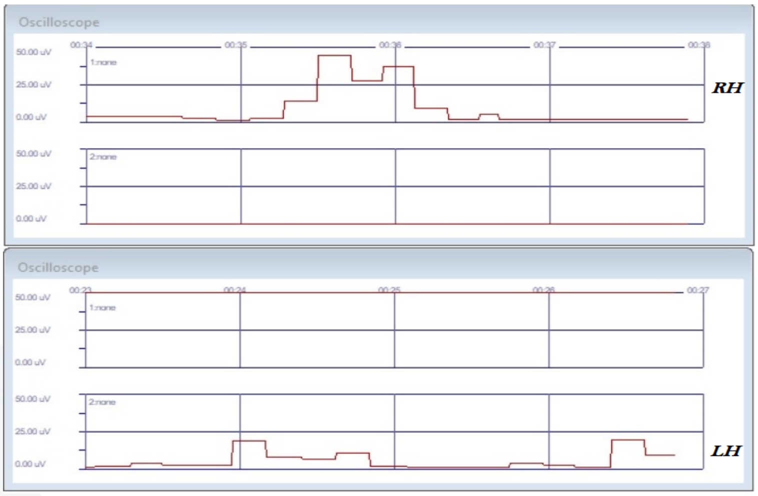

Fig. (7) EMG signals in digital form

The digital form of the two EMG signals (RH &LH) is used as an input to the XOR gate to element the similar values which represent the noise according to this research.

Finally, the output of the XOR gate is converted to an Analogue signal.

The resultant (one EMG signal) is shown in fig. (8).

Fig. (8) The final EMG signal extracted from LH & RH EMG signals.

5. Conclusion:

The most difficult problem in using measured EMG signals in control applications is the EMG features because of their variety which depend on the natural properties of human skin, and it is hardly affected by environmental factors like humidity, skin temperature, skin conductivity, and noise, besides its poor repetition and similarity during the measurement for the same muscle action.

This research presents an easy way to noise canceling and overcome the issues mentioned above by using fuzzy logic.

The spectrum analysis of the raw EMG signals will help to choose a proper filtering process.

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