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Gesture Action Recognition Based on Artificial Neural Network

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Abstract: Gesture action recognition can be widely applied in daily life. In this paper, 8 channels surface electromyographic signal (sEMG) are obtained by MYO device, after filtering and sliding integration, extracting time domain (TD) features absolute mean value, zero crossing rate and average cumulative wavelength. And achieving gesture action recognition by artificial neural network. The experiment results show that recognition accuracy is higher. The validity of the proposed method was verified.
Keywords: Surface electromyography; feature extraction; neural network; gesture recognition.

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1. INTRODUCTION

sEMG, proposed by Hermens in 1984, is an electromyographic signal (EMG) which is measured by detection electrode on the surface of the skin. It is an EMG detection way of painless and non-invasive. This way can also obtain signal without inserting into the muscle tissue, and is very convenient. It is an intuitive and active control mode to make use of sEMG signal to recognize the movement intention of user's hand and to control the artificial hand's motion. This kind of control mode, which uses arm sEMG signal as the source of control signal, is consistent with manual operation habit and moves naturally. It is the best control method for user experience at present. Then the different gestures are classified by artificial neural network and then self-learning. After many times of training, more accurate results can be obtained. It is another important research content of this project to study the recognition methods of different types of hand movements which meet the control requirements of multi-degree-of-freedom artificial hands.

2. ACQUISITION AND PROCESSING OF SURFACE MYOELECTRIC SIGNALS

2.1 The acquisition of surface electromyography signal

The MYO device is a control terminal device introduced by Thalmic Labs of Canada in early 2013. The basic principle is that the sensor on the device can capture the bioelectrical changes generated when the user's arm muscles move, thereby judging the wearer's intention, and then sending the result processed by computer to the controlled device via Bluetooth. The MYO wristband is equipped with electrodes that allow the muscle bioelectric activity to be read out when the user makes a telescopic gesture and converted into operational commands that are transmitted to the electronic device via the wireless network via software. The entire device consists of eight modules with multiple sensors, which can be worn on the user's arm to identify various actions. Unlike medical electrodes, MYO does not directly contact the skin, and the user simply places the wristband on the arm. MYO device can recognize 20 kinds of gestures, and even the slight tapping action of the finger can be recognized. The user can use gestures to perform some common touch screen operations, such as zooming in and out and scrolling up and down. In addition, MYO can automatically block irregular noise generated by others. MYO device official website said that the wristband captures the speed of the gesture is quite fast, sometimes you will even feel that your hand has not started to move MYO has already felt. This is because the muscles have activated and started to move before your fingers begin to move. This method is convenient to use, and only requires the user to wear the device on the arm, which is not limited by the specific site, and is more natural when interacting.

2.2 Judgment of starting and ending points

In order to accurately determine the starting and ending points of the action, this paper uses the combination of moving average method and threshold method to detect the starting and ending points of the action, so as to obtain the effective data segment of the action. The steps of implementing the method are as follows:

(1) Absolute the original sEMG signal for each channel of each type of action, then perform moving average (sliding length N=100), the number of channels is I (1<1<=8). The algorithm formula is as follows:

$$Sum\_Emg_I = \sum_{k=1}^{N} |x_k|, I = 1,2,...,8 \tag{1}$$

In the formula, Sum_Emg_I is the sum of the absolute values of all channels at a certain sample length, x_k is a sampling point.

(2) The summed values are then subtracted from the average. Algorithm formula of Emg_MAV_I (average) as follows:

$$Emg\_MAV_I = \frac{1}{N} Sum\_Emg_I \tag{2}$$

(3) The starting and ending points of the interception action are zero-based. In order to avoid the interference of the jitter on the start and end point of the action, after positioning a pair of starting and ending points, a resting state of a length is selected to analyze the point after the resting state.

2.3 Feature extraction

Five time-domain statistical feature are generally used as classification criteria.These are mean absolute value (MAV), zero-crossing point (ZC), slope change number (SSC), waveform length (WL), and mean absolute value slope (MAVS) .Before using the time domain feature to construct the feature vector, it is necessary to compare the selected time domain features and eliminate the features with too high similarity to avoid using redundant features in the classifier. Dimensionality reduction is performed on the time domain features using the cross-correlation coefficient in statistics.If the cross-correlation coefficient between features is too high, only one feature is retained between features, and the other feature is excluded. Therefore, MAV, WL and ZC are finally adopted. The signal meanings and calculation formulas of the three time domain features are as follows:

Average absolute value (MAV): Reflects the magnitude of the signal. Calculate the MAV of the data of the N data collection points of each channel sEMG of the MYO device. Its calculation formula can be defined as:

$$MAV_{\mathrm{i}} = \frac{1}{N}\sum_{k=1}^{N}|x_k|, i = 1,2,...I \tag{3}$$

In the formula, x_{k} is sEMG data for each sample, I=8.

Zero crossing (ZC): Reflects the fluctuation of the signal, that is, the number of times the sEMG waveform passes through the zero axis. Its calculation formula can be defined as:

$$ZC_i = \frac{1}{N}\sum_{k=1}^{N-1} f_k, \; f_k = \begin{cases} 1, & x_k x_{k+1} < 0 \\ 0, & else \end{cases} \tag{4}$$

In the formula, x_k, x_{k+1} are two consecutive data points of sEMG.

Waveform length (WL): is the cumulative length of the sEMG waveform for N data points. This parameter can simultaneously reflect the amplitude, frequency and duration of the sEMG waveform. The formula is defined as follows:

$$WL_i = \frac{1}{N}\sum_{k=1}^{N-1}|x_{k+1} - x_k| \tag{5}$$

In the study, extract 24 feature sample data of one action (ie 8 channels of MYO device multiplied by 3 time domain features).

3. GESTURE RECOGNITION

Artificial Neural Network (ANN) is adopted for pattern recognition in this paper, which is a Network system formed by a large number of simple processing units through extensive paralle1 interconnection. Its structure is shown in figure 1.

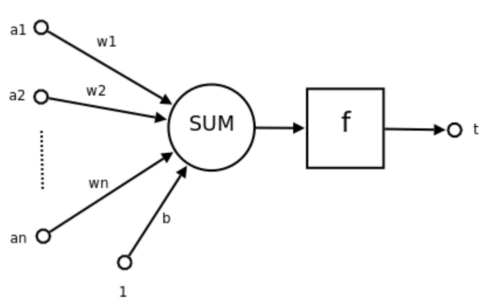


Figure 1. Structure of artificial neural network

Where a1~an are the components of the input vector, w1~wn are the weights of each neuron synapse, b is the bias, f is the transfer function, which is usually a nonlinear function. There are typically traingd(),tansig(),and hardlim(). The following defaults to hardlim(), and t is the neuron output.

Assuming that $U_i = \sum_{j=1}^{n} W_{JI} X_j - \theta_i$, then corresponding to three typical transfer functions $f(u_i)$ described as follows:

(1) Threshold function (also called the step transfer function)

$$f(u_i) = \begin{cases} 1 & u_i \geq 0 \\ 0 & u_i < 0 \end{cases} \tag{6}$$

(2) The linear transfer function, whose output is proportional to the comprehensive action of the input.

$$f(u_i) = ku_i \tag{7}$$

(3) S-type transfer function, whose output is non-linear.

$$f(u_i) = \frac{1}{1+e^{-u_i}} \tag{8}$$

The above is the most widely used and the most familiar neuron model. The artificial neural network composed of a large number of neurons connected with each other will show some basic characteristics of human brain, such as distributed storage information, adaptability, parallelism, associative memory function, automatic extraction of feature parameters, etc.

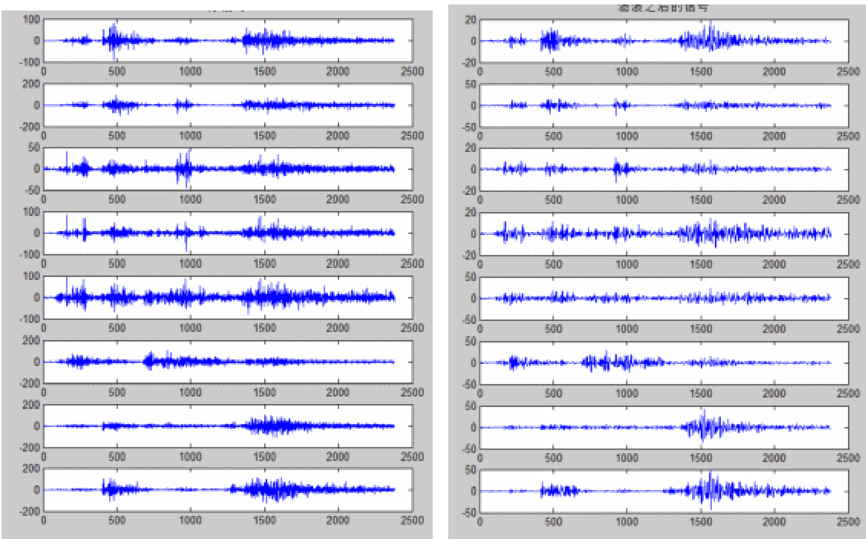
Previously, now each group of movements a lot of training, that is, the learning process. Then 24 characteristic values of a group of actions are taken as the input, and the operation of the artificial neural network can be used to obtain which group of actions belong to, namely the working process.

The operation of artificial neural network is generally divided into two stages: learning and working. The most attractive feature of artificial neural network is its learning ability. By processing multiple groups of actions made by demonstrator through neural network algorithm, the purpose of accurate classification and recognition of various actions can be achieved. It has the advantages of good classification effect, high accuracy and convenient operation.

4. Experimental result

4.1 Advance processing of data

Because the sEMG signal is very weak and is susceptible to interference, we filter the acquired signal In the advance processing of the signal. It can be seen from the following figure that the curves of the eight channels after filtering are smooth and easy to identify, so that the starting and ending points of the motion can be judged more accurately.

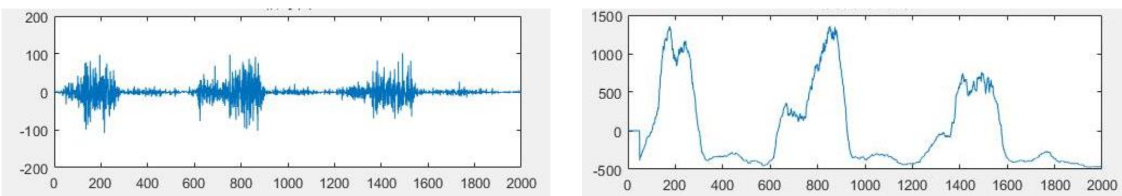


(a)raw data (b)filtered data

Figure 2. Raw data and filtered data

4.2 Sliding summation

In order to distinguish the action part and the smooth part better , we slide the signals to sum.



(a) Raw data (b) sliding summation data

Figure 3. Raw data and sliding summation data

4.3 GUI interface design

First enter MATLAB, input the guide command and it will appear GUI editing interface, select the good icon and options window according to the needs. Arrange as shown below.

Click run to generate the source file, rename the source file and use it as a call to use directly in the main program. This makes the combination of code and application interface. Click on the reading in the interface above to open the acquired signal and display the signals of the 8 channels in the image of the left half of the interface and the right half gives the judgment result. The integer of the ordinate represents each characteristic action, and the abscissa represents the number of actions of the test. From the figure, 11 sets of "6" gestures are performed, which are recognized by the algorithm and displayed on the ordinate by the code "4".

The neural network distinguishes four actions: 1 for fist, 2 for in-house, 3 for opening hand, and 4 for action "6". The following figure shows the results of the recognition of the four channels.

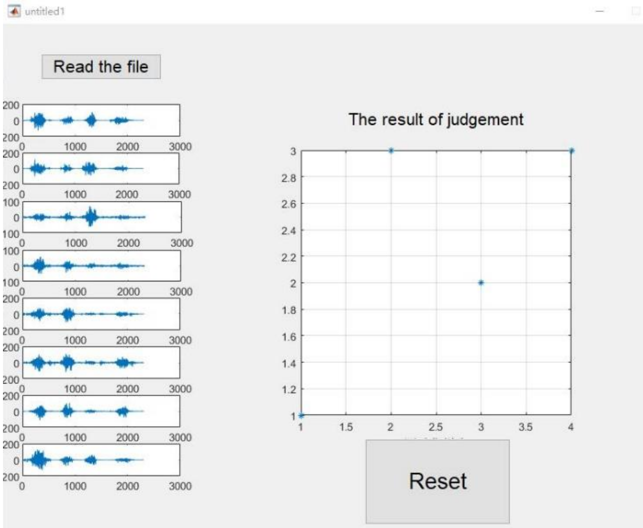


Figure 4. GUI interface

5. SUMMARY AND PROSPECT

Since the prosthetic hand plays an important role in restoring the hand function of the assisted arm amputation patient, the accuracy of the recognition becomes the top priority of the project, and thus the project has a series of advance processing and feature extraction around the problem, and finally achieved accurate classification and identification.

In the experimental stage, muscle fatigue often causes certain errors in the measurement of myoelectric signals. According to existing research, the myoelectric signal will decrease during muscle fatigue and finally affect the accuracy of the results. In addition, the complexity of the self-learning process is also an important indicator of improvement. Experimenting with more testers in the future will verify and improve the recognition accuracy of the system, by further studying to reduce the number of channels of the MYO device to reduce the influence of feature dimension on recognition accuracy, and strive to study more accurate electromyography prosthetic hand real-time control system.

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