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Research on EEG Recognition Algorithm Based on SVM Classifier

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Abstract

As more and more insight into the human brain, EEG is not only for application, processing and analysis of EEG in science and engineering field, it will also be very important in the physical, psychological and pathological studies in humans. The EEG brain - machine interface technologies to achieve the human brain and the computer or other human interface devices to communicate and control, it can provide a special kind of information exchange and live entertainment, is also disabled and a new way of control. In this paper, the collection of information preprocessing electroencephalogram (EEG) signals is proposed wavelet packet transform feature extraction method, using SVM classifier, classification based on the operation mode to achieve recognition of the EEG signal. For different individuals turn, the next turn, show fist, fist four kinds of hand motion recognition experiments show that the average recognition rate of over 80%, significantly better than the other methods to identify results.

Keyword: *Multi-modal; Electroencephalogram (EEG); Brain Computer Interface (BCI)*

1. Introduction

Now days, the rapid development of the EEG signal acquisition and control, as a new means of brain-computer interaction, has become a hot topic in recent years, rehabilitation engineering and biomedical engineering and other fields. The computer-based Signal in brain-computer interface technology, it is more and more influenced by domestic and foreign researchers' interest and attention. Feature extraction and classification of EEG data is a key factor in determining the performance of brain-computer interface, so the research on EEG data preprocessing, feature extraction, classification and recognition algorithm psychology, computer science and pattern recognition technology have a decisive and proactive role as well as the great significance, so the technology has become the focus of the interdisciplinary study.

2. EEG-Based Brain-Computer Interface System

Brain-Computer Interface interpretation is not thinking, it is only able to convert electrical signals into a computer brain can recognize a command, thus achieving control of the outside world. Brain - Computer Interface system consists of three parts, namely EEG data collection, pretreatment EEG, EEG feature extraction and device control. EEG data collection part collecting brain wave data of the human brain as a whole brain - machine interface input, and a lot of interference signals in EEG there, so the need for the

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collected EEG preprocessing, preprocessing EEG after using feature extraction and pattern recognition algorithms to extract feature information from the brain electrical activity of the collected EEG, and pattern recognition and classification device control classification results into the external environment and control equipment command, in order to achieve control external devices, such as mobile control a wheelchair or other external device. BCI system configuration shown in Figure 1.1.

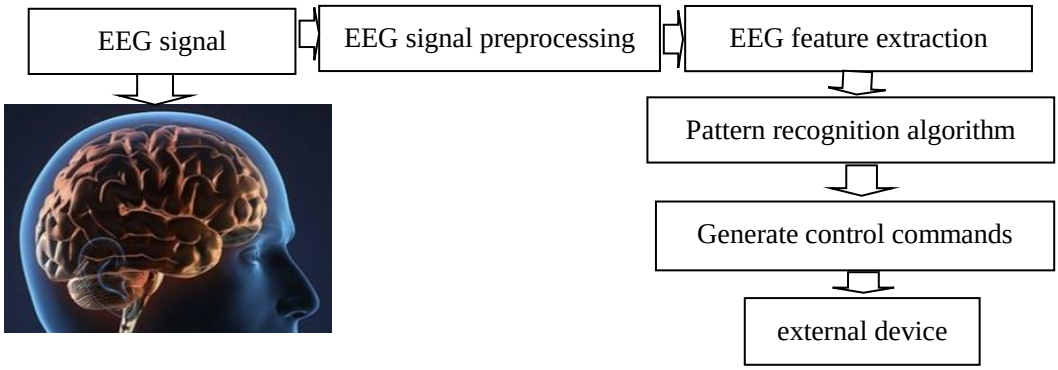

Figure 1.1. BCI System Configuration

3. EEG Definition

EEG (EEG) is the electrical activity of the brain in the absence of external stimuli arise spontaneously, it reflects the state of brain function at any moment. Through the electrode already present in the electrical activity of brain cells after the amplified recording paper, a certain pattern of curves. Different electrode placement method in accordance with, EEG can be divided into deep EEG, cortical EEG and EEG scalp. Where scalp EEG is the most common, by volume of the conductors of the electrical activity of neurons generated electric field spread throughout the scalp by electrodes on the scalp will vary scalp potentials were recorded after amplification. EEG is the randomness weak physiological signals, with a variety of types of rhythm, the same individual in different emotions, state of mind under the EEG are significant differences between different individuals as well. EEG has a rhythm, a main component according to its frequency division, including Delta waves (δ, 0.5 ~ 3Hz), Theta waves (θ, 4 ~ 8Hz), Alpha waves (α, 8 ~ 13Hz), Beta waves (β , 14 ~ 30Hz). Shown in Figure 1.2.

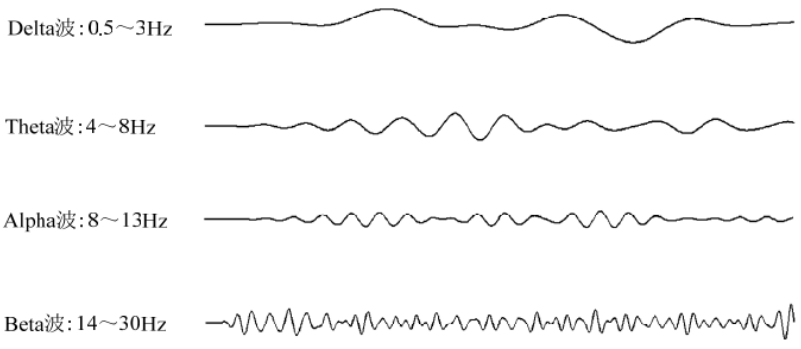

Figure 1.2. EEG Rhythms

EEG can be classified according to different frequency, and wave frequency range and amplitude of the wave what is similar to the rhythm, mainly in the sensorimotor area, so the rhythms of the brain's motor imagery of a great relationship, rhythm frequency of 8 ~ 13Hz, produced in the brain's sensory-motor cortex, the body produces rhythm games,

and will be accompanied generate rhythm at the same time. Real or imagined movement of limbs can cause the motor cortex

3.1. EEG Data Acquisition

BCI research team at the Technical University in Graz, Austria on several international research organization to carry out than earlier. Graz University of Technology data from the data 2003 Second International BCI Competition provided 7 group of 280 experiments. Mental Tasks by imagination left and right movement of the cursor control feedback. The subject is a 25-year-old normal female. All of these experiments were performed one day every two intermediate intervals experiment a few minutes, each experiment time is 9 seconds. The first 2 seconds, the subjects maintained a state of rest, at t = 2s, the accompanying voice prompt signal appears on the display for 1 second of a crosshairs, then subjects began to prepare to imagine the task. In t = 3 ~ 9s, the crosshairs becomes a left or right arrow directions, and were asked to imagine the direction of the arrow left or right movement to control the progress bar moves in the direction of arrow. Data were randomly divided into test samples (140 groups), and training samples (140 groups) in two parts. Therefore, this article is used EEG data Consciousness Task Austria Graz University of Technology.

3.2. Pretreatment EEG

Brain activity using EEG signal is generated by the outer cortical cells scalp electrodes measure, a large number of brain cells superposition result is a comprehensive response to brain activity. EEG signal can be directly and accurately reflect the situation and try thinking of pathology. Due to the existence of human ECG (Electrocardiogram, ECG), a variety of electrophysiological signals EMG (Electromyogram, EMG) and eye signals (Electrooculogram, EOG), *etc.*, so the electrode collected EEG signals usually contain a lot of interference signals, such as: EMG, ECG, eye pan and external noise, so in practical applications will be collected EEG signals some preprocessing. After sampling the EEG, especially EOG artifact amplitude is large, and covering a wide range of frequencies, the interference of the EEG is the most serious, so this paper Removal of Ocular Artifact interference signal.

EOG artifact removal of interfering signals used in this paper is the simple average of the reference (CAR). CAR refers to the average of all channels as reference signal, with respect to a reference electrode and a reference electrode signal into a signal-independent, is calculated as follows:

$$V_i^{CAR} = V_i^{ER} - \frac{1}{n}\sum_{j=1}^{n} \mathbf{V_j^{ER}}$$

Among them, the EEG of a lead $\mathbf{V_i^{ER}}$, n is the total number of leads, $\mathbf{V_i^{CAR}}$ is involved in independent test electrode signal. CAR eliminating potential component widely distributed on the scalp, highlighting the potential of a region of interest component. Figure 1.3, is EEG data Technical University of Graz, Austria adopted, Figure 1.4, for the application of the average of reference (CAR) method of interference signal EOG artifact removal.

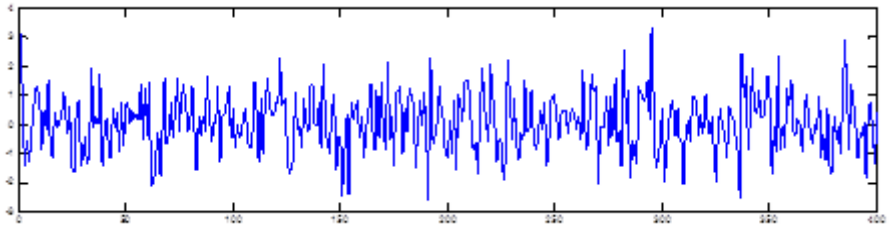

Figure 1.3. EEG Raw Data

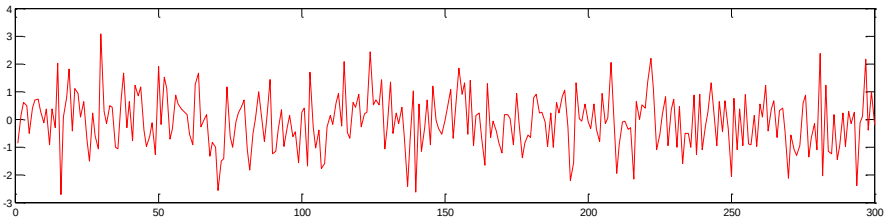

Figure 1.4. Using the CAR Method to Remove EOG Artifact Signal Interference

Thus, there are significant differences in the rhythm of the band can be seen by comparing the CAR is better to remove the interference, the amplitude of the top and bottom of the target goal of spectrum.

4. EEG Feature Extraction

The wavelet transform is a time-frequency analysis of belonging. The traditional signal analysis is based on the Fourier transform of the above, non-stationary signals the most basic and critical nature of the time-frequency localized nature, but only the Fourier transform is a global transformation, only the information signal frequency domain and therefore can not represent the signal. Wavelet transform, inheritance and development of localized Gabor windowed Fourier transform thinking, and to overcome the lack of windowed Fourier transform window size does not vary with frequency, the basic idea comes from the variable window scaling and translation, so this paper Related motion wavelet transform to extract EEG.

4.1. Wavelet Transform Theory

If a given function $\psi(t)$, if:

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi\frac{t-b}{a}$$

a, b are constants, a> 0, when a given integrable signal x (t), $x(t) \in L^2(R)$, and therefore x (t) of wavelet transform:

$$WT_x(a,b) = \frac{1}{\sqrt{a}}\int x(t)\psi^*(\frac{t-b}{a})d_t$$
$$= \int x(t)\psi^*{}_{a,b}(t)d_t \ \ \psi_{a,b}(t)$$

Called continuous wavelet transform (CWT). $\psi(t)$ Also known as the basic wavelet or mother wavelet.Is the mother wavelet, after a family function and telescopic displacement

produced, referred to as wavelet basis. Therefore, from the point of view the frequency domain, wavelet transform with different scales as roughly equivalent to the effect of using a band-pass filter to filter the signal. When a value is small, small wavelets in the time domain signal range, and is equivalent to a high-frequency wavelet analysis for higher resolution in the frequency domain; when a value is large, when the axis of a wavelet signal range large, and the equivalent of a low frequency wavelet profile as observed in the frequency domain.

4.2. Wavelet Transform Theory

In this paper, It used MATLAB software for EEG waveforms wavelet decomposition. EEG power spectral decomposition used db3 wavelet to do of the layer 6 as Figure 1.5, the first line of the original signal Pictured EEG power spectrum, the second to the seventh row in the first layer to the sixth layer signal decomposition power spectrum.

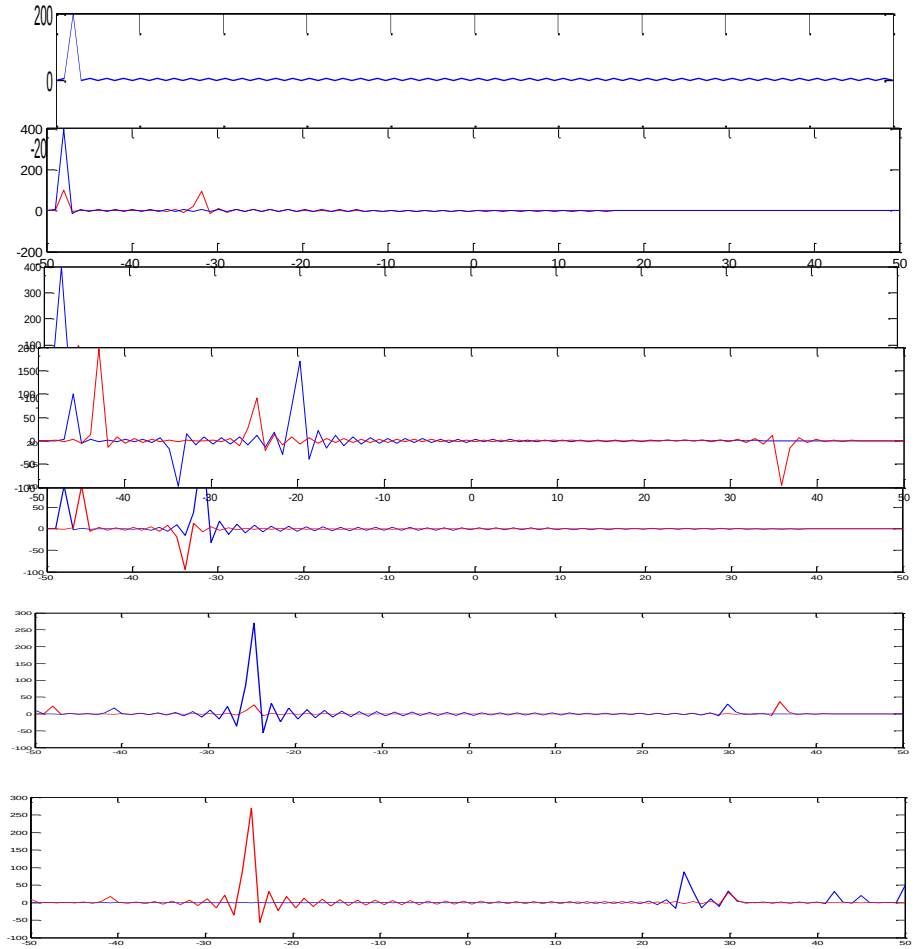

Figure 1.5. Wavelet Signal Power

The solid blue line is left to imagine the movement, the red dotted line to the right-hand movement imagination. Visible rhythm waves affected different tasks largest. Select the second and third layers of energy within the range of 10 to 15Hz as a classification characteristic. It can be seen from the graph comparison test, imagine different tasks for the second and third layers of signal power spectrum is relatively large.

5. SVM EEG Classification

SVM is a machine learning method based on statistical theory, nonlinear mapping kernel functions preselected input vector mapped into a high dimensional feature space, and then construct the optimal hyperplane. The main structure a hyperplane can be as much as two types of data points correctly separated, while the separate types of data classification surface furthest distance.

Optimal hyperplane discriminant function is as follows:

$$g(x) = w(x) + b$$

Optimal hyperplane equation is:

$$w(x) + b = 0$$

Thus, making the discriminant function for all types of samples are met: $|g(x)| \geq 1$ that the nearest surface of sample classification $|g(x)| = 1$, the classification gap will go: $2/\|w\|^2$ to meet $y_i[wx_i + b] - 1 \geq 0, i = 1,2,\cdots,n$, so that the smallest free surface $\|w\|^2$ is the optimal classification surface, $|g(x)| = 1$ called a support vector samples. Nonlinear characteristics *of* EEG signals, therefore, to identify select radial basis function as the kernel function SVM, nonlinear mapping from low to high dimensional space transformation.

Under the constraints:

$$\sum_{i=1}^{n} y_i a_i = 0, a_i \geq 0, i = 1,2,\cdots,n$$

Solving for the maximum value of the following a_i functions:

$$Q(a) = \sum_{i=1}^{n} a_i - \frac{1}{2}\sum_{i,j=1}^{n} a_i a_j y_i y_j (x_i x_j)$$

The resulting optimal classification function is:

$$f(x) = \operatorname{sgn}\{w^* x + b\} = \operatorname{sgn}\left\{\sum_{i=1}^{n} a_i^* y_i (x_i x) + b^*\right\}$$

5.1. Data Test Results

For bimodal EEG signal C3, C4 channel, the EEG signal data is divided into eight sections, each divided into a data segment 512, features a combination of application SVM recognition to 6th order AR parameter 35 dimensions, left hand, right hand two movements classification feature extraction, classification categories so as to realize the operation.

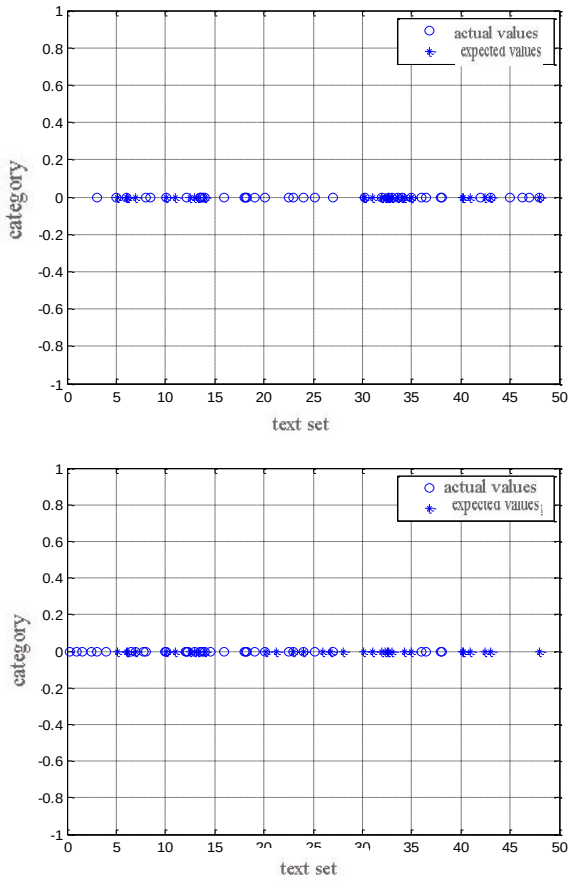

Figure 1.6. The Actual Classification and Prediction Classification C3 Channel Test Set

Based on after feature extraction left, sample test data right hand, using SVM classifier command recognition, recognition of the brain and left motor imagery condition, results right site show that the algorithm C3 channel recognition rate reached 88.2%, C4 channel correctly identified rate reached 90.2%.

6. Conclusion

In this paper, wavelet transform EEG signal acquisition feature extraction and application of SVM classification algorithm C3, C4 left channel, right brain test data, left and right movement to imagine a state classification. The correct identification rate reached 88.2% and 90.2% respectively. Application of the BCI system plays a key role in the algorithm.

Acknowledgements

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References

[1] S. G. Mason, A. Bashashati and M. Fatourechi, “A comprehensive survey of brain interface technology designs”, Ann Biamed Eng, vol. 35, **(2007)**, pp. 137-169.

[2] A. Bashashati, M. Fatourechi and R. K. Ward, "TOPICAL REVIEW; A survey of signal processing algorithms in bram-computer interfaces based on electrical brain signals", Journal of Neural Engineering, (4), **(2007)**, pp. 32-57.
[3] B. E Vaadia and N. Grand, "Challenges of brain computer interfaces in flie years to come", Front. Neurosci., vol. 3, **(2009)**, pp. 151-154.
[4] M. Negishi, M. Abildgaard and T. Nixon, "Removal of Tim-varying Gradient Artifacts from EEG Data Aequired during Continuous fMRI", Clinical Neurophysiology, vol. 115, no. 9, **(2004)**, pp. 2181-2192.
[5] Y. Gu, K. Dremstrup and D. Farina, "Single-trial discrimination of type and speed of wrist movements from EEG recordings", Clinical Neurophysiology, vol. 120, **(2009)**, pp. 1596-1600.
[6] Y. J. Wang, "Machine Interface System - from offline to online leap based rhythm-modulated brain Tsinghua University School of Medicine", PhD thesis] Beijing, **(2007)**.
[7] W. Li and Z. Xiong, "Wavelet filtering and AR model in EEG Signal Processing Applications of Electron Devices", vol. 35, no. 4, **(2012)**, pp. 461-464.
[8] Z. Yi, L. M. Wei and L. Yuan, "Wavelet transform and sample entropy EEG characteristics extraction method", Intelligent Systems, vol. 7, no. 4, **(2012)**, pp. 339-344.

