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Brain-computer Interface Analysis Based on Motor Imagination

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Abstract: *Brain computer interface technology, also known as BCI, is a kind of human brain consciousness signal collection, conversion, analysis, interpretation, finally realize the human brain to external computer control equipment directly send operation command technology, this technology can make human do not use muscle pathway feedback, can also by directly control designated muscle groups or mechanical equipment, to complete the daily body movements.Although the current stage of BCI technology has achieved some research results, there are obviously many problems in efficiency and accuracy in brain consciousness recognition.Based on this, from the perspective of motor imagination model, this paper analyzes the brain-computer interface system design of BCI technical consciousness signal recognition function, and expounds the logic idea of realizing the classification and recognition algorithm function of signal feature differentiation.*

Keywords: *Brain-Computer Interface; Awareness Recognition; Motion Imagination*

1. Introduction

Brain-computer interface technology refers to the function of directly issuing the brain nerve and operating the computer by establishing the connection between brain neurons and computer equipment. This technology has broad application prospects in many fields.For example, the clinical rehabilitation treatment of spinal cord nerve damage or muscular atrophy dystrophy, through brain-computer interface technology, can easily control muscles or auxiliary equipment to complete some basic action instructions like the normal control limb, and replace the damaged nerve system function to a certain extent.For another example, functional electric stimulation (FES) technology can only rely on eye rotation capture to help medium and low paraplegia patients recover some muscle function. However, this technology of relying on human residual muscle electrical signals is still difficult to achieve the alternative effect of all limb function. The fundamental reason is that the brain-computer interface technology is not yet developed.

2. Model Structure of BCI Technology Based on Motion Imagination

Analyzing the technical bottleneck of BCI technology has been unable to break through, it is unable to solve the logical relationship of complex instructions of the human brain, and based on motion imagination of EEG signal detection technology, through the characteristic difference identification of EEG signal, which can distinguish between different movement instructions between thinking logic generation, so that BCI technology can realize complex and efficient control function.This technique needs to undergo four steps: EEG signal detection, EEG signal preprocessing, feature extraction, and classification identification[1].The signal acquisition is divided into two implantable and non-implantable technical realization ways. The former instan electrode element in the corresponding potential stimulation area through intracranial surgery to obtain a high signal to noise ratio, but the actual operability is not high due to the surgical risk and the uncertain harm of the motor material; the latter is connected to the laying detector in the scalp position to detect EEG signals, but it will be disturbed by the eye telecom signals and other facial muscle groups.No matter which kind of installation and implantation technology, in the BCI technology based on motion imagination theory, the main structure of the brain-computer interface system is divided into four main parts: EEG signal acquisition system, EEG feature extraction system, consciousness command task classification and

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processing system, and output application system.

3. EEG Signal Acquisition System

The EEG signal acquisition system is composed of a brain wave growth device that can obtain information on electrical wave changes in brain activity by establishing connections to the human cerebral cortex to capture the postsynaptic potential stimulation signal of the top dendrites.This EEG wave signal acquisition technique is extremely accurate, especially in text information conversion, where the error rate is only below 3% level [2].When the human brain carries out some kind of thinking and logical activity, this EEG signal will be converted by the amplifier into a digital signal recognized by the computer through filter, denoising, interference, and through the AD digital mode converter.Scientific research shows that EEG signals are divided into spontaneous and evoked signals. Spontaneous EEG signals are a spontaneous electrical activity signal in the brain under relatively normal stimulation, while evoked EEG signals refer to abnormal electrical activity signals in a certain area of the cerebral cortex under specific stimulation conditions, which often have strong regular changes, such as specific periodic distribution at different stimulation time points.

4. EEG Feature Extraction System

The EEG signal itself is a power wave, which can be expressed in the form of a graph with time as the horizontal axis and the amplitude potential as the vertical axis, and the basic characteristics of EEG can be obtained by comparing the characteristic differences between the amplitude, phase of position and frequency. Through the feedback of the experimental results of the subjects, the frequency band of the EEG signal can reflect the state of consciousness of the human brain to a certain extent, and the EEG signal frequency can be divided into roughly four bands:

δ Wave, EEG signals with an amplitude range of 20-150 V, are generated in the occipital and frontal sites of the human cortex, with frequencies between the range of 0.5 and 4Hz, and are only detected in a deep sleep state, or lesion dormancy, mental weakness.

ΘWave, amplitude ranges consistent with waves, are produced in the parietal lobe of the human cortex at frequencies between 4 and 8Hz, and are detected in exhausted, hypoxic humans.

αWave, EEG signal with an amplitude range of 20-200 V, will appear in a large area of the occipital area, the frequency is between 4-8Hz range, the human body in the extremely relaxed state, will be detected, any sensory stimulation on the visual will lead to the disappearance of wave brain telecom signal, so the wave can be used as the objective basis for the human body of eye opening and closed eye state.

B wave, with a frequency of 14-30Hz, the emergence region is exactly consistent with the amplitude range of the same wave, and the [3] is only detected when the body is in high tension or suddenly frightened.

All of the above shows that the thinking activity in the human brain, can cause the characteristics of the EEG signal change, so based on the movement imagination of BCI technology, can represent the vector difference of all kinds of thinking activity as the basic basis, to the event related logic algorithm, to configure the corresponding phase-locking action.

5. Consciousness Instruction Task Classification System

Sports imagination is first used in medicine for the treatment of medium and low spinal nerve damage, or brain motor neurons damaged hemiplegia, paraplegia, even if the patient cannot make the corresponding movement function action, but as long as through the movement in consciousness, can repeatedly stimulate the corresponding damaged neural pathway, produce the same potential stimulation signal as the actual movement, which shows that the movement imagination and the actual movement of the brain working structure is completely consistent.Both the actual motion and the motor imagination can generate the event-related desynchronized potential signal (ERD) in the brain ipsilateral frequency spectrum, and the synchronous potential signal (ERS) related to the ipsilateral frequency spectrum event. The difference is only in the different amplitude, which is also the basic principle of the motion imagination model.When the amplitude of desynchronization between ERD and ERS is below 0, it indicates that the motion imagination is desynchronized by the correlation event;

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when the amplitude is above 0, the correlation time is synchronized.

6. EEG feature extraction and analysis based on motor imagination

The short data of EEG signal image and the instructions we have to process are nonlinear, so the spectral estimation analysis of BCI signal is divided into three steps: one is to choose the appropriate data sample analysis model; the second is to verify the model parameters with the autocorrelation function and the sample data; the third is to calculate the power spectrum of the model by determining the model parameters.This paper selects an AR model algorithm to minimize the error energy of forward and backward prediction by comparing a set of effective instantaneous amplitude and instantaneous frequency components.There are many criterion functions used in the AR model order, but considering that the EEG signal has strong non-stationary random characteristics, the classification accuracy function is used to define the model order.

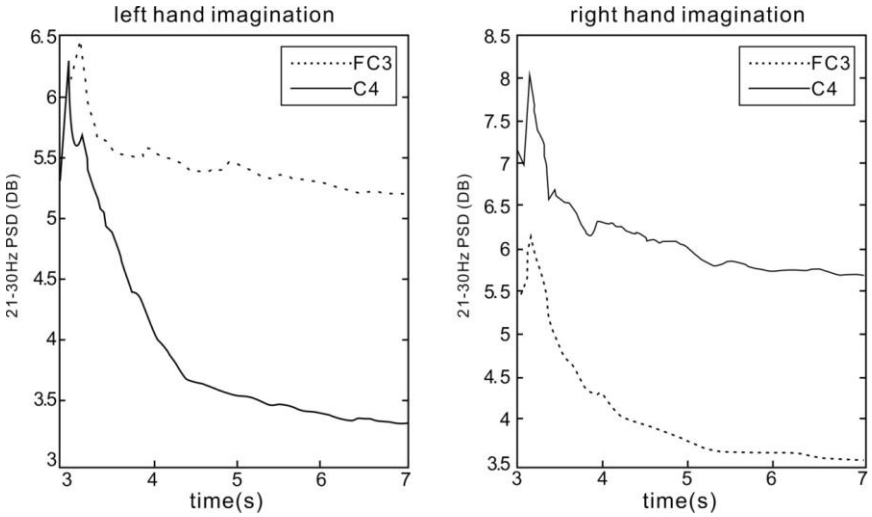

Figure 1: The density curve over time in the 21-30Hz frequency spectrum

As shown in Figure 1 are the density change curves of the EEG characteristic band power spectrum during the measured left hand and right hand motion imagination. In this set of images, we can see that when the brain imagined movement in the left hand, the EEG signal density is significantly lower than the FC3 guide density, which is the opposite in the imagined movement of the subject's right hand. The AR model, when performing the correlation analysis, is fully consistent with the theory of ERD dominance and has a high consistency with the actual imaginary motor instruction classification. In the long window within 3-7 seconds, we found that the brain on both sides of the brain length window fourth normalized accumulation will be significantly improved, but whether the right or right hand imagination movement, long window normalized cumulant result is always contralateral growth higher than the ipsilateral growth rate, and has a certain obvious symmetry characteristics. This shows that the application of the AR model has some accuracy in the EEG signal spectrum estimation in BCI technology, and that the AR model accuracy reaches 94.29% when the model order is set at 6.51s.

7. Mode Selection of the BIC Algorithm Based on Motion Imagination

However, there is still an obvious problem in the above feature extraction method, that is, when using the empirical mode decomposition method (EMD), the original EEG signal must be obtained the eigenmode component (IMF) after multiple iterations, and the orthogonal correlation between the IMF component and the EEG original signal has not been confirmed by trial. And through the amplitude calculation of ERD and ERS, a serious modal folding problem will occur in the process of iterative disassembly. This problem is due to the calculation of IMF component is based on the extreme point of the envelope, and this envelope method after many iteration calculation, the degree of envelope estimation error amplification for many times, resulting in the final IMF method is difficult to distinguish a variety of similar frequency score value, such an algorithm is obviously difficult to meet the needs of accurate control of brain-computer interface technology. Therefore, a processing method of a parameter-free empirical wavelet transformation algorithm is obtained on the basis of the EMD algorithm. The basic idea of this modal algorithm is as follows.

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The original EEG signal f (x) is divided into the form of the cumulative sum of eigenmode functions, and the formula can be written:

$$f（x） = \sum_{k=0}^{N} f_k（t）$$

Where fk (t) is expressed as the representation of the IMF function in any N + 1 eigenmode functions, while the IMF function is defined as follows:

$$f_k（t）=F_k（t）*\cos（\lambda*t）$$

λ is expressed as each component signal of IMF, with point coordinates in the two extrema in the Fourier spectrum, （λ0=0；λn=π）.Then on the IMF component of a single group, its segments can be represented by a set of matrices:

$$[\lambda n,\lambda n+1],\Lambda_{n+1}^{N}, n = 1.2.\ldots N$$

However, to further strengthen the autocorrelation of EEG signal profiling, according to the theory of the wavelet exchange algorithm, then the N-1 function boundary threshold except (0,π) is found, and then arrange all the boundary points in decreasing order to obtain the function relationship between the empirical scale “I” of the IMF component and the approximation coefficient “w”.With the sample data calculated by the above steps, we can establish the node structure of multi-layer feedforward BP neural network, take the empirical scale “I” and approximation factor “w” as the output node weight of the hidden layer of BP neural network, and confirm the vector output relationship of the single hidden layer neural network, which can train the approximation neural network through the activation function g (x).Where the activation function can be expressed in the following relation:

$$f(x) = \sum_{n=1}^{\infty} \left(T * (\cos \frac{n\pi x}{T} + b_n \sin \frac{n\pi x}{T}) \right)$$

Where “n” is the number of implied nodes of the neural network and “T” is the expected output, using the BP neural network to handle the EEG signal classification and recognition relationship, the information results are obtained in the same way as the minimum binary product effect of “Hb=T” in the EMD method.

8. Conclusion

To sum up, based on motor imagination EEG interface technology, is first through the EEG signal growth device, the human cerebral cortex position of EEG activity after acquisition, with digital mode conversion technology to generate the corresponding waveform diagram, and then according to different frequency band EEG point, frequency, amplitude difference, identify the brain at this time. In the process of realizing human brain intention recognition, the motion imagination theory of ERD and ERS amplitude is mainly used, taking the event-related desynchronous nature as the final basis for computer recognition. In order to ensure the identification accuracy of EEG signals, it must be necessary to process the nonlinear change information of thinking logic through the BP algorithm model. After repeated learning and training, the connection strength between each neural network nodes is strengthened, so that the error of the system processing information shows a gradient decline to the minimum level.

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