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The motion image recognition method based on LZ complexity analysis.

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Abstract

In this study, the LZ complexity of the nonlinear analysis method was used as the reference to process the EEG before and after the motor imagery task, and the results were compared statistically. It was concluded that the LZ complexity could be used as the feature vector to distinguish the hand grip and stretching in the whole EEG channel, and some of the EEG channels could be used in some bands. To distinguish whether there is movement; theta band can very well distinguish between the two imaginary movements; and also analyzed in motion (or imagination) before the relative calm state is not statistically different. These conclusions can provide a theoretical basis for subsequent brain computer interface experiments.

Keywords: Non-linear analysis, LZ complexity, Motion imagination, Wavelet analysis.

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Introduction

Brain-computer interface (BCI) is a kind of man-machine interface mode, which is based on EEG signals and does not depend on normal brain output channels (i.e., peripheral nerves and muscles). The research of BCI technology realizes the communication and control between human brain and computer or other electronic equipment is not only the application of human brain cognitive achievements, but also the application of BCI technology [1-3]. The research and development process will contribute to the in-depth understanding of the brain cognitive model, information flow and control mode, and also provide a new research channel and method for understanding the brain thinking model and consciousness formation mechanism. BCI research results will open a new window for the study of brain cognitive science and neuro-informatics, and greatly enrich its research content. [4,5]

Electroencephalogram (EEG) is a physiological signal recorded by scalp electrodes, which reflects the changes of electrical activity of brain cells. It contains not only a large number of physiological information, but also pathological information of brain functional lesions. Therefore, EEG signal analysis plays an increasingly important role in brain function research and disease diagnosis [6]. The main purpose of this experiment is to judge the subjects'movement content by analyzing the EEG signals. So although the main 24-channel EEG signals were collected, the main signal channels were six channels above the motor cortex, namely C3, C4, P3, P4, F3, F4.

The principles of brain-computer interface (BCI) have been fully studied, but the results of many discriminant methods are not satisfactory. Commonly used parameters include autoregressive coefficient, band energy, wavelet coefficient, SSVEP amplitude and frequency [7]. Considering that noise and electromyographic artifacts greatly reduce the ability to distinguish from each other in terms of energy, we did not use the energy burst in the observed signal to judge the behavior pattern. Considering the fluctuation of EEG signals in the related areas due to movement, the complexity should be changed obviously, and the complexity has the advantages of low signal requirement, stable output and easy recognition, so it can be applied to EEG pattern recognition [8].

This test first acquisition of EEG signals under different condition, after the pretreatment of the noise signals by using the method of wavelet transform in frequency band is divided into the alpha, beta, theta, and delta four bands and calculate the signal of LZ complexity respectively, then different movement or imagined movement under the condition of signal complexity and static coupon signal complexity comparison, discovered its statistical regularity, to pick up the obvious gap band characteristic value as to distinguish the value, finally found the effect is very significant.

Different classification methods to classify the different BCI system, due to the test at the same time analyzes the voluntary movement of EEG rhythm and imagine movement of EEG rhythm, so the results can be used to induce BCI system and spontaneous BCI system, but failed to aimed at the early stage of the movement of the brain electrical signal extraction analysis, so the experiment belongs to the synchronous BCI research, for asynchronous BCI research still need to go further.

The research idea of studying EEG characteristics through the exercise imagination task is actually quite mature, but most of them are evaluated by analyzing the energy of different frequency signals before and after the exercise or imagination task, and the evaluation accuracy can be improved through very rich algorithms.

Of course, the energy Angle is a very intuitive evaluation Angle, but the energy Angle is easy to generate noise for various reasons in the experimental process, and the high intensity of various unknown rhythms carried by EEG itself will largely interfere with the collection and judgment of motor rhythm.

The more active the EEG, the more complex the EEG should be, especially the LZ complexity representing the rate of emergence of new EEG patterns. Therefore, it should be feasible and more stable to use nonlinear dynamic analysis method instead of energy analysis method.

The experiment purpose is to distinguish the two types of motor induced rhythm and spontaneous imagination rhythm signal. It can distinguish the induced rhythm and spontaneous imagination rhythm of the bell movement type. It also analyse the short-time signal before the motion interval, and explore whether there is predictive signal.

Materials and Methods

EEG acquisition

The EMG acquisition device used in this experiment is a type of EMG synchronous acquisition device developed by Pukang company, which can synchronously collect 24 channels of EEG and 12 channels of EMG signals, the channel impedance of the device can be as low as 5K, and the EEG collected can be as low as 150V.

Subjects

The subjects are 10 undergraduate students, aged between 18 and 20 years old, all are male, right-handed, without any diseases related to the experiment, all have been trained and qualified through the experimental process.

Preparation for experiment

All the subjects had short hair and were clean and refreshing on the day. The position of the corresponding muscles of the hands were followed by hair removal, towel washing and alcohol wiping to ensure that the position impedance of EMG collection was low and the myoelectric signal could be collected. The electrode cap is properly worn to ensure that the CZ channel is at the intersection of the two mastoid connections and the median line. The electrode paste is injected into the channel hole with a special tool to ensure good contact between the acquisition end and the scalp. Meanwhile, the impedance detection part provided by the equipment is used to detect whether the channel impedance is lower than 5K. Apply the myoelectric electrode on the pea bone with the reference end and the stimulation end on the ventral side of the ulnar flexor muscle. After completion, turn on the device and its own software for electromyography detection. When there is obvious activity in the hand, the electromyography signal is normally generated and the amplitude should be within 0.5 mV [9].

After the preparation of the experiment, each subject needs to complete 20 groups of resting brain myoelectricity, 10 groups of two types of exercise tasks, and 10 groups of two types of exercise imagination tasks, a total of 60 groups of collection tasks. Each group took 3.5 seconds to collect the signal, and the time of movement and exercise imagination was 0.5 s (Figures 1-5).

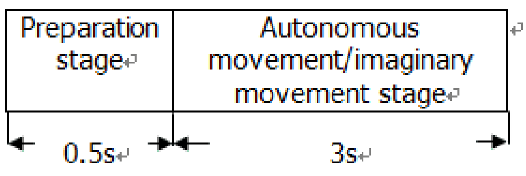

Figure 1. Schematic diagram of experimental signal composition.

The template standards for two types of movement and movement imagination tasks are shown below [10].

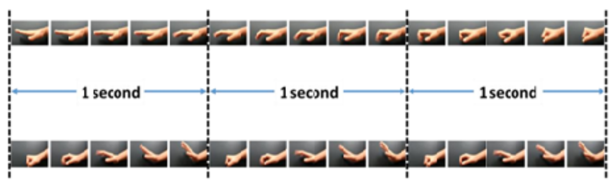

Figure 2. Motion task diagram.

Data pre-processing, LZ complexity analysis and statistical analysis were conducted in the preparation and movement stages respectively.

Analysis method

LZ complexity: LZ complexity algorithm was first proposed by Lempel and Z_{iv}, and then promoted by Kaspar and Schrster. It actually reflects the speed of LZ complexity algorithm that a time series emerges with the growth of its length. The specific process of LZ complexity algorithm is described as follows [11].

Binarization was applied to sequence X=X{X1,X2...Xn} was roughened to form the "0-1" sequence P={S1,S2..., Sn}.

For the "0-1" sequence obtained above, retrieve the new string in it successively. The new string shall satisfy the uniqueness and continuity, and separate the two strings with a "•".The retrieval process of the new string is detailed as follows:

Some strings of sequence P are represented by s, namely s={S1,S2...Sr} (r=n);The substring of S is denoted by Q, namely Q={Q1, Q2...Qm; SQ is the serial combination of S and Q, namely SQ={S,Q}; the string obtained by deleting the last character of SQ.V (SQ ft) is used to represent the set of all substrings in SQ ft;D (n) is used to represent the number of different substrings. For a given sequence, P={S1,S2..., Sn}, in the beginning, take S=S1, Q=S2, SQ PI=S1, d(n)=1. Then in the general case, that S=S1, S2,..., the Sr} (r=2, 3,...So Q=Sr +1, SQ horizon={S1,S2...If Q is a substring of s, then Q is a substring of SQ sampling and not a new substring, so that s is kept unchanged. If Q=Sr+1Sr+2, it is determined that Q is in V(SQ ft) until Q is not in V(SQ ft), then Q={S1,S2...Sr+I} does not belong to SQ set={S1,S2...,Sr+i-1}, then d(n)+1. Repeat the above process in turn until the last character.

Calculated the number of strings divided by "•", defined as complexity d(n).

In order to obtain the complexity that does not depend on the length of the sequence, d(n) needs to be normalized. Lempel and Ziv study on random sequences belonging to [0,1] interval found that almost all d(n) tend to have a certain value as n goes to infinity, i.e.,

$$D = \lim_{n \to \infty} d(n) = b(n) = n/\log a(n)$$

In the formula, b(n) is called the asymptotic behaviour of a random sequence, n is the sequence length, and a is the number of different characters in the string ("0-1" sequence a=2).

D (n) was normalized by b(n), and the LZ complexity of normalization was obtained as follows:

$$D(n) = d(n)/b(n) = d(n) \times \log a(n)/n$$

Results

Comparison between resting state and two different modes of motion

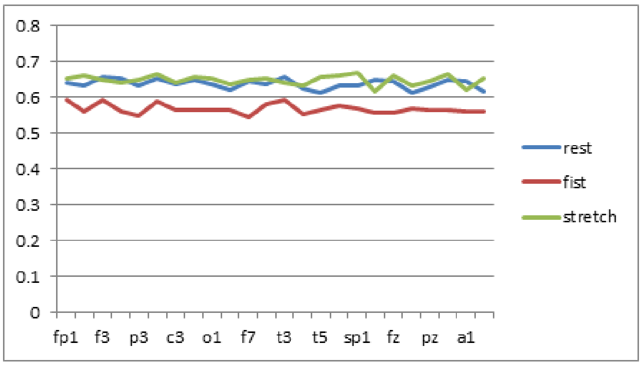

Figure 3. Comparison diagram of autonomous motion in alpha band.

From Figure 6, we can clearly see that the complexity of only three signals in beta band cannot be clearly identified. Besides, the complexity of the other three frequency bands can clearly distinguish the motor rhythm signals generated by two kinds of movements (Figures 7-9).

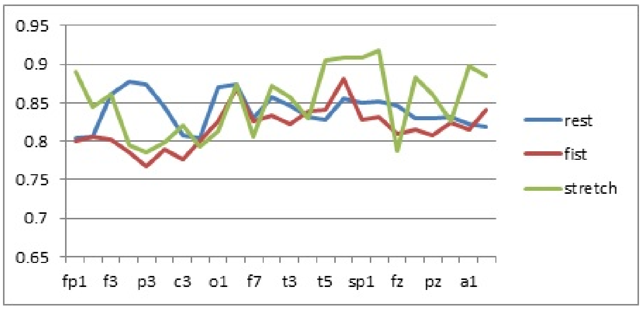

Figure 4. Comparison diagram of beta-band autonomous movement.

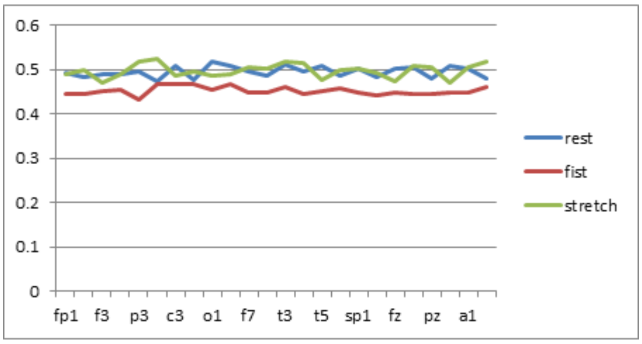

Figure 5. Comparison diagram of autonomous motion in theta band.

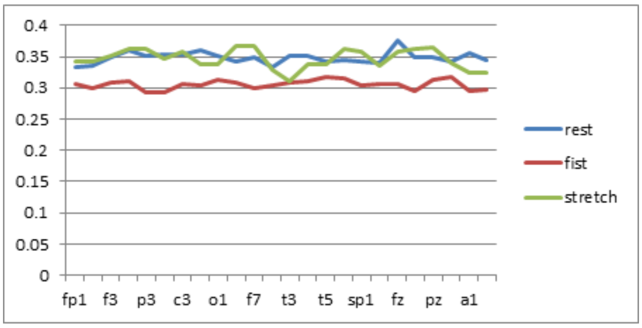

Figure 6. Comparison diagram of autonomous motion in delta band.

The ability to distinguish between imagined movements and autonomous movements

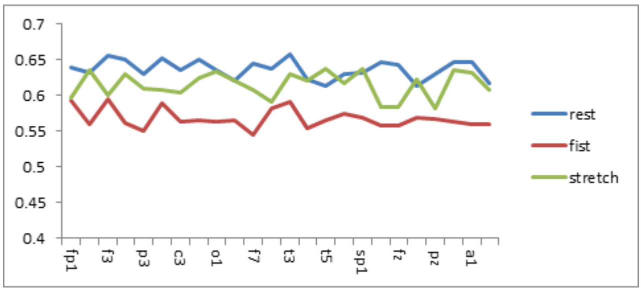

Figure 7. Schematic diagram of the distinction between clenched fist and imagined clenched fist at alpha band.

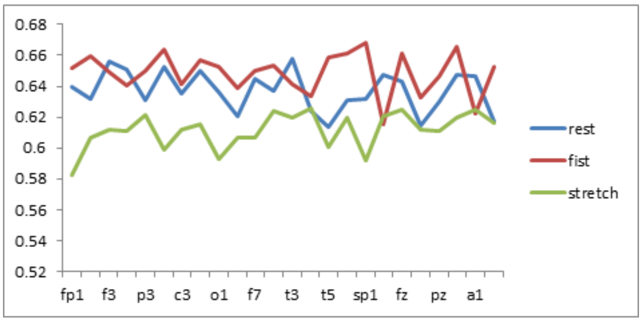

Figure 8. Schematic diagram of the alpha band to distinguish Zhanquan from imaginary Zhanquan.

Pre-motor EEG analysis

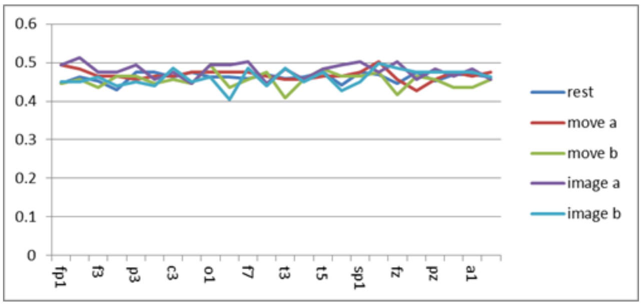

Figure 9. Schematic diagram of the results of the alpha band in the preparation phase.

Discussion and Conclusion

This experiment found that by conducting LZ complexity analysis and statistical analysis on four bands of EEG, this analysis method could be effectively differentiated from certain angles, which was helpful to the brain-computer interface experiment. The main content is as follows.

The first conclusion is that complexity can distinguish between two types of autonomic EEG rhythm, and this conclusion can be used for remote control of patients with mobility inconveniences. When the user grasps at a distance, the motor rhythm can be identified through analysis and intelligent life assistance can be conducted according to the predetermined action pattern.

The second conclusion is that LZ complexity can effectively identify two kinds of motion imagination patterns only at c3 channel. Since all the subjects involved in the experiment are right-handed and the movement mode is implemented by right hand, EEG channels in the motor area of the lateral brain area are the focus of attention, and only obvious identification here is also the confirmation of previous conclusions. The gain of being able to identify two types of motor imagination patterns is that it can be used for the study of brain-machine interface. In addition, functional electrical stimulation devices can achieve the imagined control of functional electrical stimulators and control of hand muscles to achieve the purpose of skipping peripheral nervous system to control the body, which brings good news to the paralyzed patients and patients with cerebral trauma sequelae.

The third conclusion is that EEG rhythm can distinguish autonomous movement from imaginary movement. In the future, I believe I will have a set of system equipment, either by hand the autonomous motion control of the mechanical equipment, also can by imagining a motor control equipment, due to distinguish between two ways of imagine rhythm and two ways of movement rhythm is not unified, so the first step to distinguish the movement rhythm or imagine the rhythm is very important, because the distinction between these two movements threshold is consistent, can distinguish what kind of rhythm is before to distinguish what kind of action.

Fourth conclusion is through testing or imagine movement of 0.5 seconds before the found no can distinguish between channel or signal, and this is we use the complexity of this kind of analysis method of temporary still can't find that exercise in advance or imagine movement rhythm, only able to periodically test delay after the analysis of the data, in turn, sends out control instructions

References

1. Vaughan TM, Wolpaw JR, Donchin E. EEG-based communication: prospects and problems. IEEE Trans Biomed Eng1996; 4:425-430.
2. Wolpaw JR, Birbaumer N, Heetderks WJ, McFarland DJ, Peckham PH, Schalk G, Donchin E, Quatrano LA, Robinson CJ, Vaughan TM. Brain-Computer Interface Technology : A Review of the First International Meeting, IEEE Trans Rehab Eng 2000; 8:164-172.
3. Vaughan TM, Heetderks WJ, Trejo LJ, Rymer WZ, Weinrich M, Moore MM, Kübler A, Dobkin BH, Birbaumer N, Donchin E, Wolpaw EW. Brain-Computer Interface Technology:A Review of the Second. IEEE Transactions On Neural Systems Rehabilitation Engineering 2003;1:94-109
4. Baoguo X, Guoqing S, Shumin F. Method of feature extraction and classification of EEG signals in the online EEG interface. Electronic J 2011; 39:1025-1030.
5. Banghua Y, Guozheng Y, Guoqing D. Research on the key technology of brain-computer interface. Beijing Biomed Engg 2005; 24:308-310.
6. Zhao Y, Yu Yi, Yan C, Si YJ, Zhang HX, Shi LJ. Method for automatic removal of ophthalmic pseudotrace in EEG signals of patients with schizophrenia. J Xinxiang medical college 2016; 33:113-115.
7. Qinghua H, Chenglin P, Baoming W. Research methods of brain-computer interface technology. J Chongqing University 2002; 25:106-109.
8. Zhou P. Research on brain-computer interface based on motor imagination. Tianjin University 2007.
9. Choi I. A Sensorimotor Rhythm (SMR)-Based Brain-Computer Interface (BCI) Controlled Functional Electrical Stimulation (FES) for Restoration of Hand Grasping and Extension Functions 2017.

10. Zhang Y, Liu C, Liu H, Wei S. A coded Lempel-Ziv complexity for analysis of physiological signal complexity. J Biomed Engg 2016;33:1176-1182.
11. Chen X. Analysis and improvement of binarization method in LZ complexity algorithm. J Jiangsu University 2004; 25:261-264.

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