Research on A Brain Computer Interface for Population

Lili Zhou, Zhichao Zhang, Corresponding author: Tongjun Liu*

Institute of Intelligent Manufacturing, Heilongjiang Academy of Sciences, Harbin 150090, Heilongjiang

zhoulilivip@126.com, dyhd4007@163.com, ltjvip@126.com

Abstract. Brain Computer Interface (BCI) technology is the key core technology of the new generation of human-computer interaction. The development of BCI can be divided into academic exploration stage, scientific demonstration stage, and application experiment stage. The research of BCI will lead the research of brain science and brain like intelligence in China. In the application research of brain computer interface at this stage, reducing training time and widely applying in groups is an important public relations direction for the implementation of brain computer interface technology. This paper performs a play on the brain computer interface technology of applicable groups to solve the key problems in the application of brain computer interface. It is concluded that the evoked brain computer interface based on steady state visual stimulation has strong group applicability and is easier to achieve industrial implementation at this stage. The group characteristics of steady state visual evoked stimuli are described below.

Keywords: Brain computer interface; human-computer interaction; Steady state visual stimulation; Group application;

1 Introduction

From the extraction of brain signals in the 1920s to the development of software and hardware conditions in the 1990s, the high-precision acquisition technology of brain computer interface has become increasingly mature. Based on the research of brain project at home and abroad, the further development of neurodynamic models, the EEG acquisition of brain computer interface has gained more theoretical support and moved towards practical application. For example, medical rehabilitation, scientific research, control and interaction, meta universe, etc. Commonly used brain functional imaging methods for BCI to monitor brain conscious activities include: electroencephalography (EEG) [1]. electrocorticogram (ECoG) [2]. magnetography (MEG) [3]. functional magnetic resonance imaging (fMRI) [4]. and near infrared spectroscopy (NIRS) [5]. After nearly 30 years of research, the theory of brain computer interface has been improved and the algorithm has been enriched. Now it has gradually passed the laboratory stage and is ready to be implemented. In the further research of brain computer interface, in order to achieve the mature implementation of brain computer interface system, the

H. Wu et al. (Eds.): CSIEDE 2022, ACSR 103, pp. 721–727, 2022.
https://doi.org/10.2991/978-94-6463-108-1_80

following issues need to be paid attention to:(1) Signal recognition accuracy; (2) System training time; (3) The algorithm and database are suitable for the group.

The physiological principle of brain computer interface is that large electromagnetic signals will be generated during the conduction of neurons. EEG acquisition equipment collects the common discharge of a group of neurons. In fact, it is difficult for us to obtain the situation of a single neuron. This collected signal is just a common result of many neuron signals, and its spatial resolution is very low. However, the advantage is that it has a high time resolution and can capture millisecond level nerve impulses. However, in contrast, although MRI and other imaging technologies have high spatial resolution and can judge brain activity in a small area, their temporal resolution is very low and requires a long imaging time.

2 Comparison of common EEG signals applicable to groups

In the research of brain computer interface, EEG has the characteristics of high temporal resolution and low spatial resolution. It is a signal generated by the discharge of brain neurons, which can better reflect the activity state of the brain and is extracted based on the theory of brain function map research. The types of EEG signals can be divided into many types according to the frequency band. In this BCI study, the following three classifications are used: Steady State Visual Evoked Potential (SSVEP), P300 potential and Motor Imagery (MI). In the first two cases, EEG signals are generated in the cerebral cortex after being induced by external stimulus, which are induced by fixed frequency visual stimulus and rare event stimulus respectively; The latter belongs to the electrical signals generated by endogenous neuronal discharges in the brain. Compared with the endogenous spontaneous EEG signal and the exogenous induced EEG signal, the EEG signal characteristics collected by the brain self discharge activity induced by foreign aid are obviously conducive to analysis, can reduce the data training in the classification process, and can quickly obtain effective features for application, which has more natural advantages for the wide application of brain computer interface technology. Different potential bands are shown in Table 1

Table 1. Different potential bands [Owner draw]

band	Frequency band	Occurrence position
Delta	<4Hz	frontal lobe, Occipital lobe
Theta	4-8Hz	parietal lobe, frontal lob
Alpha	8-13Hz	Each area
Beta	14-30Hz	Central frontal area
gamma	>30Hz	Frontal area and anterior center

The structure of brain computer interface system for EEG acquisition is shown in Figure 1. The brain computer interface system of EEG acquisition collects EEG signals through acquisition devices. The functions of EEG acquisition devices include EEG

acquisition and EEG electrolysis code. EEG acquisition platform should ensure high accuracy and low noise to measure subjects' EEG information.

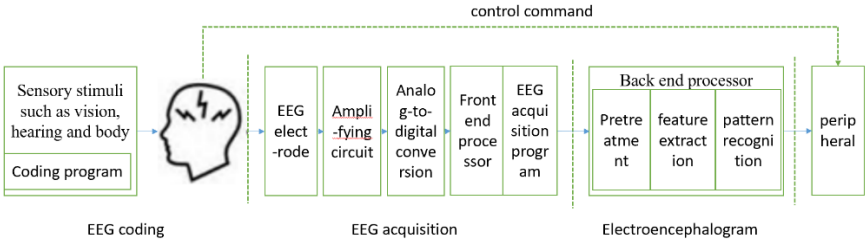

Fig. 1. Brain Computer Interface System Structure [Owner draw]

Steady state visual evoked potential is to apply a fixed frequency of visual evoked stimulus to the subject, requiring the subject to focus on the stimulus source, and then produce a response in the occipital cortex. This response is extracted through the EEG BCI platform. This signal is a continuous and specific EEG signal, which is related to the stimulus frequency of the evoked signal. The frequency characteristics of this visual evoked EEG signal are closely related to the frequency of the stimulus signal. The response characteristics of different subjects are obvious, and the individual differences are very small. It is suitable for a wide range of applications in the brain computer interface technology.

P300 is an exogenous, cognitive related event related potential, which is characterized by a positive peak of eeg signal about 300 ms after the target event [6]. P300 wave has a large amplitude and a wide span, usually distributed in the parietal area of the brain. P300 potential has four characteristics. 1. P300 signal was generated about 300 ms after a random signal induced stimulus; 2. The amplitude of evoked potential is related to the psychological impact of the stimulus event on the subjects. 3. The potential signals stimulated by accidental events were obvious. The characteristics of SSVEP and p300 are frequency characteristics and time domain characteristics respectively. The brain computer interface based on p300 potential has the characteristics of no training and small individual differences [7].

Based on the endogenously designed brain computer interface, the commonly used EEG signal is called motor imagery (MI). When the brain imagines a behavior, but this intention is not transmitted to the executive motion actuator, the brain's intention will generate a leading EEG signal. The signal is mainly mu band in alpha band and beta band near the central groove. The characteristics of motor imagery potential signals are mainly reflected in the spatial domain. Compared with SSVEP and p300, the characteristics in the time domain and frequency domain are not obvious, but the resolution in the spatial domain is low. Therefore, the application of endogenous motor imagery EEG signals to the brain computer interface system needs to further solve the problem of spatial resolution and further research.

Therefore, there are different brain computer interface paradigms corresponding to different types of EEG, such as endogenous motor imagery (MI), exogenous evoked EEG SSVEP, P300 paradigms. Brain computer interface systems based on endogenous

potential paradigms often require a lot of training for subjects, with large pattern differences among individuals and sometimes low recognition rate. In contrast, the brain computer interface system based on the exogenous evoked potential paradigm is less difficult for the subjects to train. Among them, SSVEP paradigm has the advantages of stability, rich instruction set, and high information transmission rate.

3 EEG Signal Processing Based on Steady State Vision

Steady state visual evoked potential (SSVEP) is a fast and stable visual stimulus to subjects using a fixed frequency, which causes the occipital cortex potential response. The overlapping of these responses produces a steady state oscillation. The frequency domain characteristics of the response are obvious. The average method or frequency analysis method is used to analyze and process the average value or peak value of the response.

(1) In terms of preprocessing of EEG signals, SSVEP raw signals usually include other physiological electrical signals and clutter interference signals from the senses. The signal processing of SSVEP is mainly to process the frequency characteristics of the signal, and the common method is to filter and remove noise. In this paper, the common IVA algorithm based on natural gradient is used to iterate the convergence data in a fixed step descending manner. Before the EEG signal is reconstructed from the extracted features of the stable value, the artifact must be removed by preprocessing.

(2) In terms of feature extraction of EEG signals, the commonly used feature extraction method of binary common space pattern, when the traditional common space pattern is applied to the experimental system with small sample size, is faced with the disadvantage of unstable feature segments caused by small samples, which affects the stability of the system. EEG signals can resolve many kinds of information, and people's emotions, physical conditions, and individual differences will affect the characteristics of the signal, so the EEG model obtained by increasing training samples is difficult to apply in groups. Therefore, this paper aims at the fixed frequency characteristic relationship between evoked potentials and evoked factors, and analyzes the response caused by evoked signals, so as to exclude other strong factor interference as a solution.

(3) In terms of classification and recognition of EEG signals, the current commonly used multi-level classification method belongs to the tree classification, but EEG signals have complexity and similarity, which will produce a non corresponding relationship that can be classified in the positive direction but not backward, affecting the accuracy of the system. Moreover, the feature that the classifier can not update itself in real time determines that it can not adapt to future sample changes. Therefore, the typical correlation analysis is selected in this paper to analyze the positive trigonometric function waveform of evoked EEG potential. It does not need to stack too many data samples, which is more conducive to the wide application of brain computer system.

4 System implementation

The BCI system based on SSVEP consists of two parts: the acquisition of electrical signals from the occipital cortex and the processing of evoked potential information. Its principle is shown in Figure 2. The structure of the system is: collect the potential signal of occipital cortex through wet electrodes, and then process the signal, including preprocessing (amplification, noise reduction and digitization), extracting EEG signals with common characteristics, determining the subject's intention through typical correlation analysis, using a spelling machine as a carrier, converting them into language control signals, and transmitting them to external application equipment.

Fig. 2. System Function Schematic Diagram [Owner draw]

The first part is signal acquisition: the function of the signal acquisition module is to amplify the occipital cortex potential signal, and transmit the amplified signal to the signal processing unit for noise reduction processing and classification. The part mainly includes the wet electrode cap, amplifier, filter and A/D converter. The second part is signal processing: the signal processing module is the core part of BCI system, and the main process includes signal preprocessing, feature extraction, classification and recognition. Preprocessing is to remove the noise interference in the signal to the greatest extent through principal component analysis, independent component analysis, nonlinear filtering and other methods, and extract the effective information of EEG signals. Feature extraction is to extract the EEG information applicable to the Chinese character compiler from complex EEG signals by transformation calculation, and then classify the information into control commands.

The research goal of this paper is to induce the occipital cortex potential through the steady state visual input of the population, and explore the potential changes of the occipital cortex potential under the steady state visual evoked. The main technical feature is that we can conduct brain stimulation acquisition experiments on individuals and groups through color, pattern, scene, text, scene and other visual input signals, and analyze and identify the obtained data. Through the experiments, we can establish a human brain vision EEG mapping model, and realize the analysis system of using EEG to conversely analyze visual information. Compared with the traditional EEG recognition system, this paper focuses on the multivariate EEG of categories and feature areas in the EEG analysis process, pays more attention to the establishment of group feature model, and improves the universality of the model while keeping the individual accuracy as much as possible. Visual stimulation, the system chooses a more flexible software mode. The FPGA with high efficiency, flexibility, portability and other

advantages shall be selected as the hardware. FPGA has good real-time performance, which is very suitable for the application requirements of BCI. It can accurately control the timing of stimulus and replace the computer to complete the coding task.

5 SSVEP Online System Experiment

Table 2. Test Results of 8 Groups of Subjects [Owner draw]

Subjects	Number of successful people	Success rate
A	9	90%
B	8	80%
C	8	80%
D	8	80%
E	9	90%
F	9	90%
G	8	80%
H	9	90%
Average results	8.5	85%

The system realizes steady state visual stimulation through software, as shown in Figure 3. The software evaluates the accuracy of BCI system group application through the output results of the speller. The subjects selected 8 groups of people, 10 people in each group, took the average accuracy rate of each group, and recorded the results. After several tests and optimizations, the results are shown in the table.

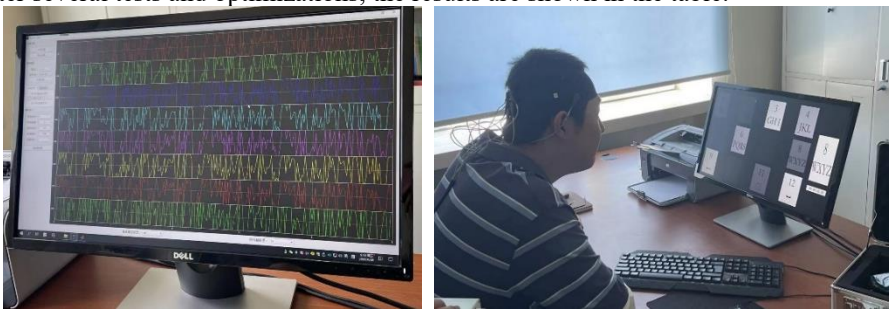

Fig. 3. Brain computer interface system test [Owner draw]

6 Conclusion

The software and hardware related technologies for constructing EEG BCI systems are becoming increasingly mature, and the emergence of more technologies and equipment suitable for groups will promote the gradual transformation of BCI from scientific research equipment to daily life application equipment. In the future, it will be widely used in medical rehabilitation, human-computer interaction and other fields. Depending on the development of brain science, accurate extraction of required signals will

become the key technology for the development of BCI applications. With the growth of theoretical knowledge, the development of high-performance hardware, and the updating and iteration of algorithms, more brain computer interface research will focus on the characteristics of group applicability and better industrialization. The application of EEG BCI will permeate all walks of life.

References

1. CONGEDO M, BA R ACHANT A, BHATIA R.Riemanni-angeometry for EEG-based brain-computer interfaces; aprimer and a review[J].Journal Brain-Computer Interfaces,2017,3(4):155-174.
2. BRANCO M P, FREUDENBURG Z V,AARNOUTSE EJ, et al.Decoding hand gestures from primary somatosen-sory cortex using high-density ECo G[J].Neuroimage,2016(147):130-142.
3. SCHARTNER M M,CARHART-HARRIS R L,BAR-RETT A B,et al.Increased spontaneous MEG signal di-versity for psychoactive doses of ketamine,LSD and psi-locybin [EB / OL]. (2017-04-19) [2018-01-18].
4. CALHOUN V D, ADALI T,PEARLSON G D,et al.In-dependent component analysis of f MRI data in the com-plex domain.[J]. Magnetic Resonance in Medicine,2016,48(1):180-192.
5. SHIN J, M LLER K,HWANG H J. Near-infrared spec-troscopy(NIRS)-based eyes-closed brain-computer inter-face (BCI)using prefrontal cortex activation due to men-tal arithmetic [EB / OL].(2016-11-08) [2018-01-2-19].
6. D.J.Krusienski, E. W. Sellers, D. J. Mc Farland, et al. Toward enhanced P300 speller performance [J]. Journal of Neuroscience Methods, 2008, 167(1): 15-21.
7. E.Donchin,K.M.Spencer,andR.Wijesinghe.The mental prosthesis:assessing the speed of a P300-based brain-computer interface [J]. IEEE Transactions on Rehabilitation Engineering, 2000, 8(2): 174-179.