The current development of the non-medicine treatment of Epilepsy involved EEG and the Expectation

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Abstract. Since Jacquces Vidal first proposed the concept of the brain-computer interface in 1973, more and more scientific researches have been involved in the study of BCI, leading to the rapid development of BCI technology. Brain-computer interface refers to establishing a direct connection between the human brain and the external machine, which enables the brain to directly interact with the outside world based on the behaviours and movement of muscle tissue regulated by peripheral nerves or the communication of language and characters. BCI can achieve direct contact with external devices without relying on normal brain output pathways, which brings hope to patients with normal thinking but a severe neuromuscular injury that BCI can restore their ability to move or communicate with the environment and improve the quality of life of patients. There are mainly EEG, MEG, ECoG and FMRI methods to record neural signals of brain physiological activities. EEG is the bioelectrical activity of cortical neurons, which can reflect different brain states well and is widely used to apply brain-computer interface technology. At present, BCI technology is developing towards the real-time and practical direction. This paper summarizes the progress of EEG based brain-computer interface and an overview of epilepsy. These results shed light on further exploring the application potential of BCI in repairing major brain diseases.

Keywords: BCI, epilepsy, EEG

1. Introduction

One serious problem that blocks the treatment of epilepsy is the drug resistance of the disease. 50 million patients worldwide have epilepsy, 22.5% of which are drug-resistant [1]. These patients have a greater risk of injury, premature death, mental disorders and a very poor quality of life.

Generally, some developed methods effectively avoid the drug-resistance of epilepsy. Specifically, once the patient is diagnosed with drug-resistant epilepsy, it is necessary to evaluate whether surgical treatment can be carried out as soon as possible, especially for patients with unilateral hippocampal sclerosis or other respectable foci [2]. There are various surgical methods, including anterior temporal lobectomy and lesion resection (e.g., glioma, vascular malformation etc.). Sometimes, even if no obvious lesions are found on MRI, they can still be surgically removed as long as the functional imaging indicates abnormalities. Besides, palliative treatment can also be applied. If the epileptic focus cannot be removed, it can also interrupt the important transmission route of epileptiform discharge, i.e., palliative treatment. For example, corpus callosum incision, multiple subpleural transaction, hemispherectomy or functional hemispherectomy, etc. Vagus nerve stimulator is another method of placing a pulse generator in the upper chest to control epilepsy by discharging to the vagus nerve. It has become an adjuvant treatment for drug-resistant partial paroxysmal epilepsy in patients over 12 years old. Moreover, the Ketogenic diet for children with drug-resistant epilepsy seems to be effective for all types.

This paper is divided into three parts. The subsequent Sec. 2 will introduce both the pathology of epilepsy and the principles of EEG. Afterwards, Sec. 3 will evaluate the current status of EEG curing epilepsy. Then, the short expectation of the field is presented in Sec. 4. Finally, a brief summary is given in Sec. 5.

2. A basic description for the pathology of epilepsy

Epilepsy is a kind of transient and recurrent brain disorder caused by the abnormal discharge of brain neurons. It has complex clinical manifestations, e.g., Paroxysmal motor, sensory, autonomic nerve, consciousness and mental disorders. There are many pathologies of epilepsy. The difficulty in the treatment of epilepsy is due to the diversity of its etiology and inducements, including genetics, brain damage, related risk factors, national living habits and customs, and the uncertainty of clinical manifestations. Therefore, it is usually considered that epilepsy is the sum of a large class of diseases, sometimes called "epilepsy syndrome".

2.1. Pathology of epilepsy

The etiology of epilepsy is very complex. Specifically, it may be caused by physiological lesions or by psychological factors. In addition, some patients come on because they carry relevant genes. The reasons attributed to epilepsy are listed as following:

Epilepsy with genetic factors: The clinical manifestations are typical and easy to diagnose, and usually, these patients carry the gene that is related to Epilepsy.

Neurotransmitter: The occurrence of epilepsy is mainly due to the excessive synchronization of brain neurons, and neurotransmitter plays an important role in it. Effects of glutamic acid (Glu), aspartic acid and taurine on seizures Promote, and γ-Aminobutyric acid and glycine play an important role in epilepsy inhibition [3].

Ion channel: Ion channel gene mutation is closely related to epilepsy. When the gene encoding ion channel protein mutates, it can affect the function of the ion channel, which causes abnormal changes in the excitability of nerve tissue, leading to the occurrence of epilepsy. Sodium, potassium and calcium channels are associated closely with epilepsy [4].

Infection and immunity: Central nervous system infection is the main risk factor for epilepsy. Besides, more and more evidence suggests that inflammatory processes play an important role in human epilepsy.

Some systematic disease or local lesions: For example, temporary cardiac arrest, carbon monoxide poisoning, excessive anesthesia, etc., may cause muscle clonus of limbs and trunk and even directly cause generalized seizures.

2.2. Manifestation

The generalised seizures are listed as following:

Major, also known as tonic clonic seizure, is guided by the foreboding (including visus, olfactory, dizziness or numbness and electric shock in their limbs), followed by the loss of consciousness, muscle rigidly, and twitching of body, accompanied by abnormal eye movement [5]. Tonic seizure, mainly for children, is characterized by continuous, strong and non trembling contraction of the whole body or part of the muscles and fixing the patient's limbs or body in a certain position [6].

Clonic seizures always appear in young children, loss of consciousness, accompanied by the sudden muscle contract, and always happen during febrile disease.

Myoclonic seizure is a generalized or relatively limited sudden, transient, lightning like muscle contraction

Minor, it can be divided into typical absence and atypical absence:

Typical absence suddenly disturb the consciousness and suddenly stop, and some patients can recall the scene of this time after the stop. Additionally, this disturbance is also accompanied by stereotyped actions such as making clicks, aimless groping, and rubbing hands, etc.

The atypical manifestation of the seizure is that the beginning and end of the attack are relatively slow and change gradually. The degree of Italian supply disorder varies, which can be not obvious or change gradually.

Atonic seizure, the atonic seizure is characterized by a sudden decrease in muscle tension. If it involves the whole body, it can lead to the patient falling. However, if it only involves some muscle groups (e.g., head and limbs), it will result in nodding, limb kneeling, etc.

3. Basic principles of EEG

The classification of BCI is helpful to summarize the current research status of the BCI system for rehabilitation treatment and helps establish a general framework for BCI system design and key technologies for extracting different types of EEG signals. BCI can be divided into invasive and non-invasive types according to how the signal is detected (as illustrated in Figure 1).

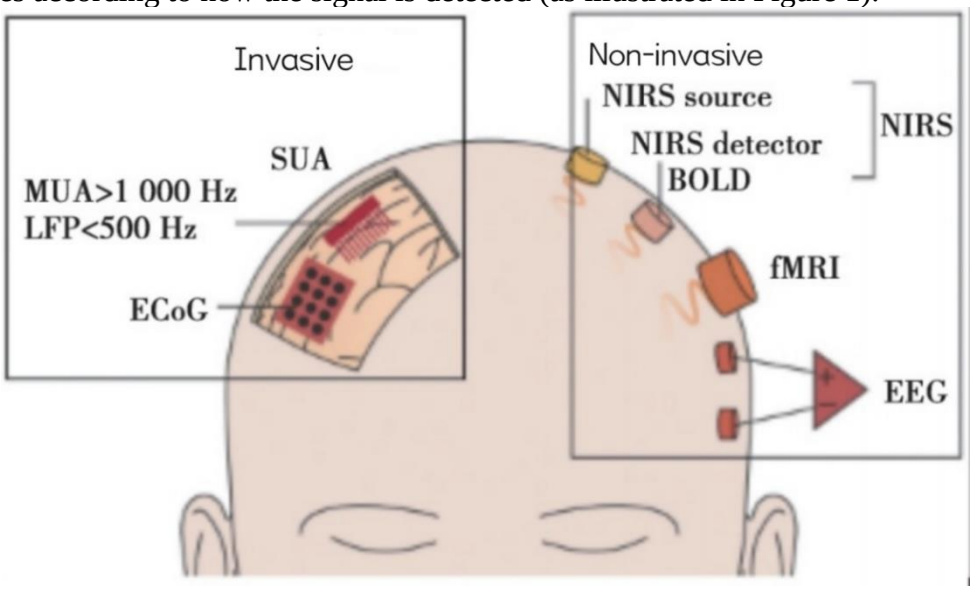


Figure 1. The BCI is classified into two types according to the way the signal is detected [6]

Invasive BCI measures the activity patterns of neurons in the cerebral cortex by surgically implanted electrodes. There are four main types of neuronal activity associated with behavioral patterns, local field potentials (LFPs), single-unit activity (SUA), multi-unit activity (MUA) and electrocorticography (ECoG). Non-invasive BCI uses specific detection devices to record neuronal activity on the surface of the scalp in the form of functional magnetic resonance imaging (FMRI), functional near infrared spectroscopy (FNIRS), blood-oxygen-level-dependent (BOLD), magnetoencephalography (MEG) and electroencephalography (EEG). EEG has the advantages of simple acquisition equipment, high time resolution and easy operation, which has become the most used method in non-invasive BCI system research. A sketch of the BCI interface is displayed in Figure 2.

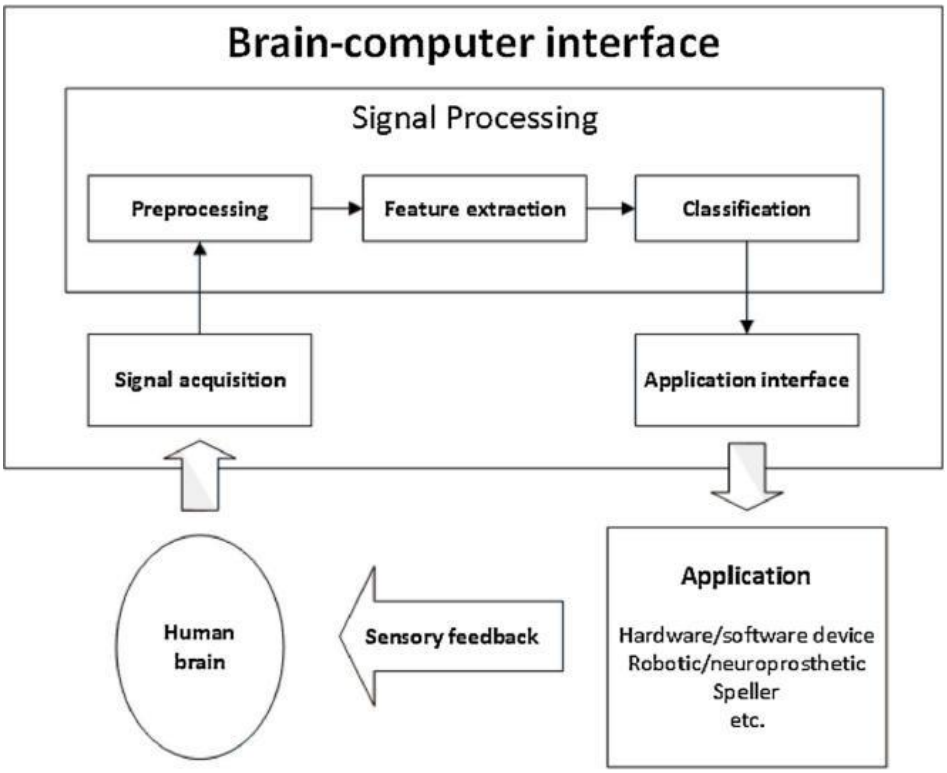


Figure 2. An overview of the brain computer interface (BCI) closed loop [7]

4. The development of EEG applied to cure epilepsy

The whole process of epilepsy is detecting the irregular brain wave and locating the damaged part of the brain. Owing to the properties of low cost and high efficiency, technologies related to EEG have been the focus point in the field of epilepsy treatment. However, the duration and paroxysm rate of epileptic seizures appear usually with highly random irregularity. Thus, the time taken by doctors to analyze the massive data collected from EEG, i.e., technologies based on EEG, appear.

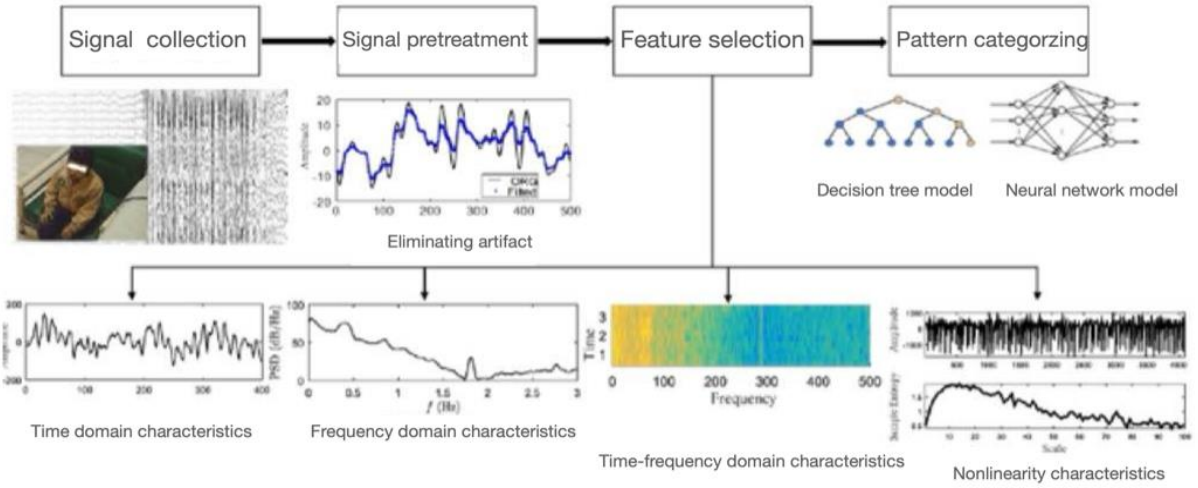


Figure 3. The process of automatic detection of epilepsy [8]

4.1. Automatic detection of epilepsy

These technologies are mainly used in Seizure Event Detection (SED) and Seizure Onset Detection (SOD). SED recognizes signals of epileptic seizures from multiple EEGs as many as possible. However, SOD needs to record every time period of an epileptic seizure. The process mainly contains

four steps: signals collection, pretreatment of signals, features selection and patterns categorizing (Seen from Figure 3).

Signals collection: There are two kinds of signals: encephalic EEG and scalp EEG [9]. In detail, Encephalic EEG is collected by placing electrodes on the endocardium through craniotomy. The scalp EEG also requires electrodes to be attached to the scalp and record signals [9]. These EEG signals collected can be used as the input signal for automatic detection of epilepsy

Pretreatment of signals: Because some incredible facts might disturbing collection, a filter is needed to exclude all obstruction, usually band pass filter.

Feature selection: After analyzing the signals, valid features of epileptic EEG signals are extracted to comprehensively characterize the signal mode and describe the differences of EEG signals between seizure and normal state [10].

Patterns categorizing: The categorizing methods major contain statical and robotic.

4.2. Corpus Callosum commissurotomy

The idea of the surgery is based on the conclusion of brain-split experiments performed by Roger Sperry in the 1950s.

Basic principles: the surgery needs to block the connection between the left and right brain by cutting off the Corpus Callosum. Thus, the signals will not be able to transfer unconsciously.

Advantages: The treatment physically removes the damaged part of the brain, i.e., the sequels of epilepsy are highly unlikely to appear.

Drawbacks: The left and right brains are not connected, so two brains work individually. Some brain function is no longer used together. Thus, there will be such an inconvenient situation that a patient can not right because the left brain controls the right hand, but the language center is in the right brain.

5. Conclusion

In summary, we investigate the usage of quantum technology brain-machine interface in dealing with epilepsy. Specifically, we discuss the pathogen and manifestation of epilepsy. The pathogen mainly including neurotransmitters, ion channel and immunity. Besides, the EEG signal is analyzed, which is important for the brain-machine interface. EEG signal can reflect the situation of epilepsy in a short time, i.e., two technologies called SED and SOD are demonstrated, which use EEG to detect epilepsy. Contemporarily, epilepsy is impossible to cure quickly and completely. The traditional course of epilepsy has many limits, i.e., it can not have an effect on all patients. In the future, the development of a brain-machine interface gives us chances. We will focus on the application of the brain-machine interface in treating epilepsy. These results offer a guideline for the successful combination of the brain-machine interface and the treatment of epilepsy. The successful application of the brain-machine interface in epilepsy will allow epilepsy to be treated completely in the future.

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