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Quality improvement in home life based on EEG signal

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Abstract. The purpose of this research is based on the EEG and environmental signals, which are collected by different sensors and uploaded to the same server wirelessly. On the one hand, it is convenient for the data storage and data calls at any time; on the other hand, the system can provide a health advice with adjusting to the environment spontaneously, or to use EEG for the control part of the electrical equipment. The people, objects, and the environment will be organically combined to create a more comfortable, more suitable environment for their living.

1 Introduction

Brain waves[1] refer to the brain in the active state and the physiological changes in the activity of neurons when the potential changes. The potential activity of nerve cells in different regions represents different activities of the brain, which can be controlled by analyzing the characteristics of EEG signals. For example, in clinical practice, through observation of brain waves can determine epilepsy incidence causes, incidence area and so on. Brain waves can carefully distinguish their difference between a variety of intracranial diseases, which have great help for diagnosis.

In 1924, the German psychiatrist Becker (H. Berger) extracted the brain waves and record it for the first time. And then scientists began to conduct in-depth exploration of brain waves. Because brain waves are uncertain and uncontrollable, the progress is slow. University of Washington[2] has published a study showing that there is a set of procedures that can be used to decode and judge the collected EEG signals in a timely manner, and to see the responses of different EEG signals on the screen. Chines company called EEGSmart have developed the machine which can be used to control the light bulb switch and brightness etc.

2 Brain waves and brain-computer interface

Brain waves are spontaneous and rhythmic, the frequency of which depends on the state of the brain's neurons. Now the study of EEG is mainly concentrated in the following bands:

Delta wave (1~3Hz), about 20~200μV, which will appear in the baby or unconscious state; theta wave(4~7Hz), the average amplitude in 100~150μV, which often appears in adolescents or adults' mental depression; alpha wave (8~13Hz), which have the range of amplitude frequency at 20~100μV. When people in the sober moments of the gentle mood, the band is very clear; and beta waves (14~30Hz), 5~20μV, when the mood is very excited or in the excited state, this band can be detected.

In addition, there are some specific brain waves. For example, when people are on the state of awake and focusing circumstance, it can be detected by a gamma wave higher than beta wave frequency, which have frequency range from 30Hz to 80Hz. The shorts are uncertain on its amplitude range; some more special brain waves may also be detected when in sleep, such as σ wave, λ wave and so on[3].

But the EEG signal is relatively weak, sometimes about microvolts. The more the surrounding disturbance signals are, the more difficult the signal acquisition is. Especially for EEG signals which have been collected already, there have also been some ocular artifacts, EMG artifacts, heartbeat pseudo[4] and so on. It is also need to do a series of artifact removal process, which will cause the signal

acquisition and signal processing very complicated. Beyond the external interference, people's own emotions, unstable health, the external environment perception will also cause the EEG signal different and uncontrollable[5].

EEG can not only change the different potential reaction in the process of neuronal activity in the diagnosis and treatment for the disease. More importantly, the essence of EEG signals is the same as voltage and current of analog signal, which could also use in the analog to digital conversion, input into computer for feature extraction and classification the data. The external signal can be compared with the database, and then output control signal characteristics represented. So, it is easy to control external equipment with of brain computer interface.

In 1988, Farwell and Donchin from the United States Illinois University have designed a virtual BCI typewriter based on the characteristics of P300, which is the world's first BCI system based on P300[6]. Research team led by Professor Pfurtscheller Graz of the Austria University of science and technology have developed two sets of BCI system called Graz I and Graz II[7], to solve the classification problem in the imagination of motion. Later in 2004, they have a design of Asynchronous BCI system, which can make patients imagine a movement via the left or right hands, such as grasping and throwing with the help of this system (combined with functional electrical stimulation) through long-term training; The team of Li Yuanqing in the South China University of Technology have developed the efficient implementation of the Internet and wheelchair control function[8]; Gao SHANGKAI team in Tsinghua University have designed a spelling system based on the motor imagery -VEP serial mode BCI character to improve the flexibility and maneuverability[9]; Xu Minpeng in the Tianjin University have improved the virtual character of input system in the paradigm with the combination of P300 and SSVEP[10].

3 EEG signal processing

In the process of experiment, the Ag/AgCl electrode can be used by setting up three electrode probes, one of which is used as the reference electrode. It also can be placed in accordance with the international practice of the 10-20 system electrode, which are usually applied in multi-channel acquisition[11]. The analysis of multiple signals often obtains more accurate results.

First of all, the sampling rate should be set, because the amount of acquisition channels and data is much large. Secondly, the reference electrode is reset to remove unwanted noise. Once we are doing EEG signal acquisition experiment, we generally set both sides of the ear lobe electrical signal as a reference signal. So, choose T7 as the reference electrode when filtering. After pretreatment of the data, the relevant information such as the sampling rate, the number of channels, the epoch, the reference electrode and other information will be displayed on the toolbox interface.

MATLAB have equipped a variety of filtering methods. Here we will choose the way of FIR filtering for EEG signal processing. Select the FIR filter on the interface with low pass value for 1HZ, and then reopen the filter interface for the choice of high value. Because there may be interference in EEG, here we choose 50Hz. The waves filtered was presented as figure1.

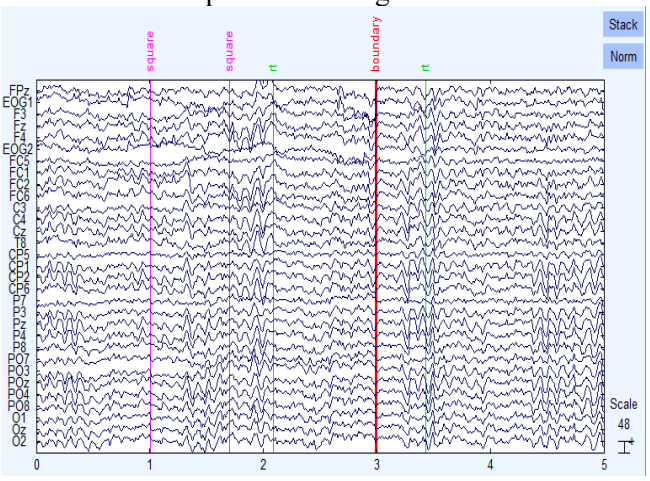

Figure 1: EEG waves after filtering

Next is the process of artifacts removal and feature extraction. The utility model can effectively separate the interference signals in the EEG signals (including the eye electricity, the EMG, and the 50HZ power frequency interference), without destroying the characteristic of EEG signals, and even enhance the signal of some important features. And then the processed signal will be transmitted to the host computer through the ZigBee node.

4 Design of smart home

The system architecture can be divided into three modules: data acquisition module, which means sensor node network, intermediate data transmission module and the final data processing module. The sensor for data acquisition includes temperature and humidity sensors, light sensors and environmental sensors to collect EEG signal, which have been dealt before; and next is sending data to the CC2530 chip for the collected data summary. The placement of all the sensors are showed as followed, figure2.

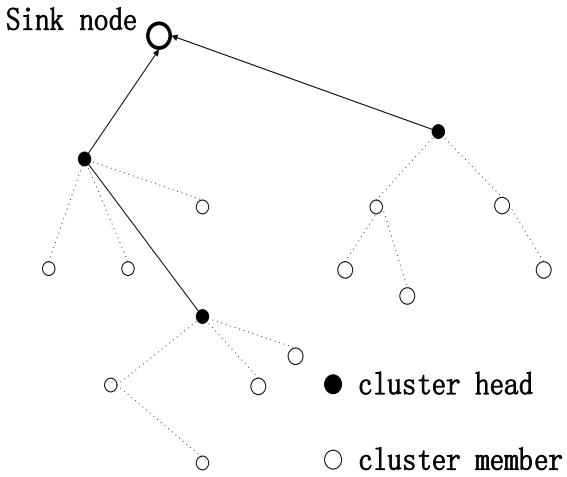

Figure 2: Sensor placement

Then the coordinator module connected to the CC2530 chip in the ZigBee network will realize the wireless transmission. Finally, the core board program will be judged according to the input signal from corresponding control instruction and control various electric appliances or equipment.

Features of CC2530 are listed as followed and the real chip is presented, just like figure 3.

1) 2.4-GHz IEEE802.15.4 compliant RF transceiver;
2) Excellent Receiver Sensitivity and robustness to interference
3) Suitable for systems targeting compliance with worldwide RF

Figure 3: CC2530 chip

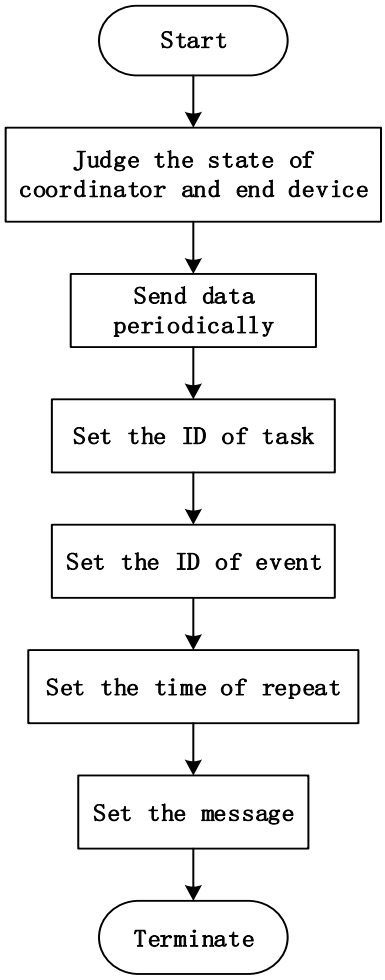

Figure 4: Send message in wireless way

The terminal equipment is an intelligent management system with external touch screen and keyboard. It is an integrated chip of a series of elements. The coordinator and the processing chip are connected via the serial port for data collection and transmission. There is large capacity storage device equipped in this intelligent system for the reading and saving of image or data. External touch screen can view the various parameters of the environment in real time and the button can also control the normal operation of the various systems. The remote control is sending collected data by setting the router into TCP/IP format and upload to the network. the ZigBee network will relate to external WAN for effective data transfer. Users can use the computer or APP by Internet or mobile 4G network and get real-time parameters of environment.

The system can be intelligent for controlling of the light intensity, temperature and humidity in the family. When there is no one at home, it can control home appliances into the dormant state. On the other hand, if the owner is about to enter the house, the system will keep the environmental quality at a comfortable range by commanding all kinds of equipment; while the person is at home, the system can control the lighting through brain computer interface without touching the mechanical equipment, which is more intelligent. Compared with ordinary home furnishing, which have the simple function of provide shelter on the premises, the intelligent home furnishing will provide a higher level and more pleasant living area and optimize the use of resources. Home Furnishing which are furnished the function of intelligent communication in this system can also make the communication between people and families more interactive.

5 Summary

This study puts forward the concept of "green" life, "green" life is not only reflected on the normal range about indicators of physical function, but also expressed health requirements of the living environment, and so the value of air temperature and humidity, PM2.5. That the health from the inside to the outside is what we want. Brain-computer interface system, which is well-known in many disciplines recently, is different from the traditional channel for information communication between human brain and environment. Apparently, BCI is a new method for interaction between human and computer, in which way the brain can communicate with the outside world directly. The design includes the acquisition of biological signals, environmental signals, and then use the ZigBee node for the home networking. And then the collected data will be aggregated and stored. Once a problem is found, it is immediately reported to the police. The acquisition of EEG signal also needs to be enlarged and filter processing, which would achieve the requirements of AD conversion and then transferred to the host computer for feature extraction. In the end, the household electrical appliances switch will be controlled through the wireless network.

Hope that the future of this system can be further optimized and improved, including the node selection, installation and function optimization of PC software, and so on. It will be applied to the actual environment or the "green" living.

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