# PROCESSING AND TRANSMISSION OF EEG SIGNALS

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## Abstract

Relations between spatial attention and motor intention were investigated by means of an EEG potential elicited by shifting attention to a location in space as well as by the selection of a hand for responding. High-density recordings traced this potential to a common front parietal network activated by attention orienting and by response selection. Within this network, parietal and frontal cortex were activated sequentially, followed by an anterior-to-posterior migration of activity culminating in the lateral occipital cortex. Based on temporal and polarity information provided by EEG, we hypothesize that the front parietal activation, evoked by directional information, updates a task-defined preparatory state by deselecting or inhibiting the behavioural option competing with the cued response side or the cued direction of attention. These results from human EEG demonstrate a direct EEG manifestation of the front parietal attention network previously identified in functional imaging.

## 1. INTRODUCTION

The methods in examining brain diseases are improving continuously in recent years. Due to the advantages of non-invasive measurement and the capability of long term monitoring of the EEG signal, the electroencephalograph machine plays an important role in brain examination and study, question system would be enhanced significantly.

The one of purposes of this study is to improve the conventional architecture of electroencephalograph. In this work, a multi-channel EEG recording system is proposed. The Bluetooth module is adopted as transmission interface such that the wire lines between the EEG acquisition circuit and computer interface are removed. This also avoids serious signal distortion and provides better quality

EEG signals. Owing to the features of energy-saving and easy development, the TI-MSP 430 chip is utilized for serving as core processor in the digital circuit.

Therefore, the digital filter can be implemented in the digital circuit to filter out the noise from the EEG signal and make the electroencephalogram reproduce with low distortion. Using the system, the non- successive brain activities such as epilepsy, sleeping disorder and abnormal behaviour can be measured. To provide an effective EEG reading program on PC or

PDA, a simple but effective classification process of the EEG signal is conducted. Under the condition of long-term recording of EEG signal, the activities of penitent always cause disturbance during observation. To achieve correct reading for EEG signals it is necessary to develop a specific algorithm to perform signal processing tasks. Therefore, this work divides the processing task for recorded EEG signal into subtask including segmentation , characteristics extracting, and clustering. A modified bisecting means algorithm is also proposed to classify the EEG signals into simple and understandable groups of waveforms. For doctors or researchers, this algorithm is applicable to syndrome diagnosis from the acquired specific EEG signal of sleeping and can facilitate the follow-up study of brain diseases.

Once the EEG signals had been acquired, they were converted by ADC circuit into digital form and then pre-filtered by the digital filter built-in MSP 430 chip. These pre-processed data remove the outliers and make subsequent signal clustering task easier and better. The processed signals are transmitted to the back-end via the Bluetooth module. The proposed classification algorithm is applied to the recorded signals to execute off-line analysis, which is described in detailed as follows.

## 2. MAIN TEXT

Electroencephalography (EEG) has long been used as a standard tool to localize the sources of brain electric activity.

Nevertheless, this technique shows limitations in the spatial resolution with which these sources can be localized as well as difficulties related to nonexistence of a unique solution to the EEG Inverse Problem (IP). ([1]−[2]).

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The segmentation, feature extraction, and classification of pre-processed EEG data complete the signal clustering task. The flow chart of EEG signal classification is illustrated in right hand side of Fig. 1.

The EEG signals in various time points possess different statistic feature. This means that the EEG signal is a

A detailed introduction of segmentation, characteristic extraction, and sequence of classification are described in the following

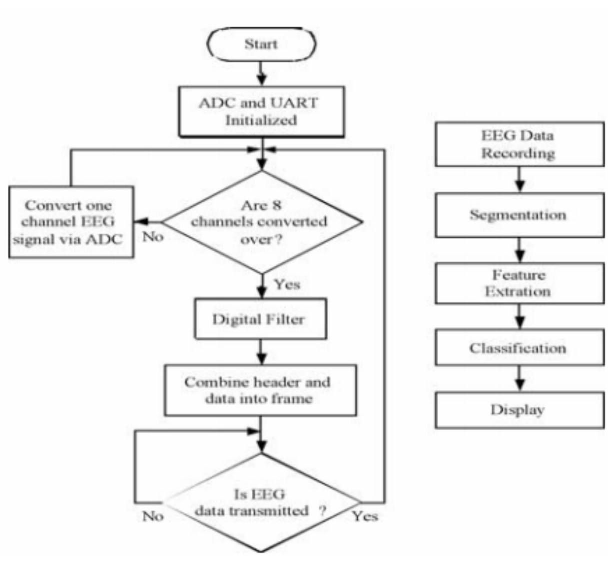


Fig 1. Flowchart for EEG signals processing from data acqusion to classification

Signal segmentation is usually based on the energy and frequency of signal [7-8], and the difficulty mainly comes from that the energy and frequency may vary simultaneously. In general, the EEG signal changes due to different physiological and psychological status, and is called a time varying signal. Therefore, for analysis of the EEG, the signal has to be divided according to its characteristics.

## 3. ILLUSTRATIONS

An EEG signal is usually acquired through silver-chloride covered electrodes, though sometimes other materials like pure silver, tin, steel or gold are used. The signal amplitude is only a few microvolt and needs to be amplified several thousand times before it can be captured. Because it is faint, the signal can very easily drown in noise, particularly 50/60Hz hum from the mains which is transmitted capacitive (i.e. by an electric field) from the wiring in your house.

To handle this, the signal is first amplified by a high quality instrumentation amplifier, which measures the voltage difference between two locations on the scalp. In the example in the previous section, we used C3 and P3. This ensures that a large percentage of the mains hum never enters the system, because the level of the mains hum on those two locations is essentially the same. Afterwards the signal strength is increased further by normal amplifiers, and passed through a low-pass filter which minimizes distortion caused by so-called aliasing that may occur when the signal is converted to digital samples. Below is the block diagram of one EEG amplifier channel, and the Right-leg driver (DRL-circuit).

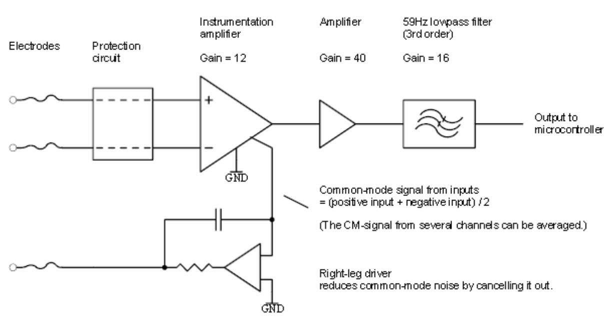


Fig. 2. Simplified block diagram of the …

Some parts are not included here. The schematic gives you all the details if you are interested.

The EEG signal is picked up by the two topmost electrodes and passed through the protection circuit. It serves two purposes: First, it protects the circuitry from electrostatic discharge (ESD) and second it protects the user from failing circuitry. Leaving the protection circuit, the signal enters the instrumentation amplifier where it is amplified 12 times. After that, the signal is amplified about 40 times in a second amplifier stage. You can't see it in the diagram, but there is a reason for splitting the amplification into two steps like this. Between the two stages there is a high-pass filter which removes DC-voltage offsets. Some electrode materials, such as gold or steel, are polarization. This means that electric charge can accumulate on the surface of the electrode, building up a relatively large DC-voltage, sometimes several hundred mill volts if you are unlucky. In theory, you would amplify a 200mV signal 480 and get a 96 volt output. In reality, the circuitry can handle about 2.5V so the output signal would be stuck at a maximally high or low level, usually +/- 2.5V and not contain any EEG. The high pass filter tries to solve this problem. Finally, the signal is amplified 16 times more and low pass filtered. The filtering is done to prevent aliasing effects later on, when the signal is digitized. Below the signal amplifiers, and the filter, sits a third amplifier pointing the other way, seemingly sending a signal to the user. This is the right-leg driver. It is named like this for historical reasons. The driver is, and was, previously only used by ECG meters, which measures the electrical activity in the heart. During ECG sessions, the driver (also abbreviated DRL, for Driven Right Leg) is attached to the right leg, as far away from the heart as possible. The purpose of the DRL is to reduce common-mode signals such as 50/60Hz mains hum, by cancelling them out. It replaces a ground electrode which older EEG designs use, and can attenuate mains hum up to 100 times more than the instrumentation amplifier can do by itself. After the filtering, the signal is ready for acquisition by the analog-to-digital converter which in our case is located inside a microcontroller. The microcontroller sends the digitized EEG to a PC via a standard serial cable. To protect the user from electrical faults, the EEG device is electrically isolated from the PC and external power sources. The block diagram below shows this.

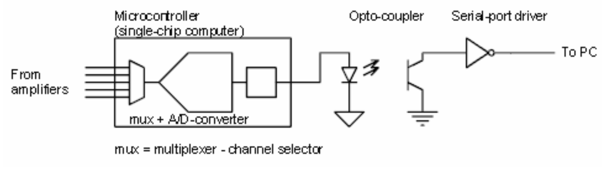


Fig. 3. Simplified block diagram of the Modular EEG microcontroller, opt coupler and RS232 interface.

## 4. CONCLUSION

The architecture of Bluetooth wireless multi-channel EEG recording system is studied in this paper. The wireless transmission mechanism eliminates wire-line connections. Also, the signal filtering and digitization in the system reduce the possible noise interference. In contrast with the current EEG recording systems, such improvements make this multi-channel EEG signal measuring system more applicable to studying on non-consecutive brain diseases. To verify the practicality of the proposed system, a sinusoidal testing signal is transmitted via the Bluetooth module.

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