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The EEG measurement technique under exercising

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Abstract— **Our purpose of the research is a development of the detecting method of EEG under exercising. Usually, measuring EEG is done in the quiet state. In case of the measuring EEG under exercising, a movement of the body causes vibration of electrodes and artifact for the EEG. Therefore, generally detection of the EEG under exercising is said to be difficult. So, we developed the measuring method of EEG under exercising by using algorithm that we designed. Five normal subjects were tested with our method, and EEG without artifact were able to be measured in all cases**

Keywords— **ElectroEncephaloGram(EEG).**
Acceleration censer.
Adjustment noise cancellation.

I. Introduction

Some vital signs(for example heart rate, blood presser, and so on) show the body condition of an athlete under exercising. However, we cannot evaluate mental condition of the athlete by these vital signs. If we'd like to assess the mental condition, EEG will be a good sign for this purpose. Because, the change of power spectrum of EEG has relation to the change of psychological condition. And we can estimate the mental condition of the athlete by evaluating EEG. For example, stress makes change the frequency band of EEG to high. So, our objective of this study is detecting human's EEG under exercising. As follows show the relationship between frequency band of EEG and mental condition

δ - rhythm・・・Band:0.5~3[Hz]
→Under unconsciousness and a deep sleep.
θ - rhythm・・・Band:4~7[Hz]
→Shallow sleep and a relaxed state.
α - rhythm・・・Band:8~13[Hz]
→While being devoted to meditation and concentration something, when mentally stable.
β - rhythm・・・Band:14~30[Hz]
→Worries and strain and working promptly.

However, it is said that measuring EEG under exercising is difficult. Because, the amplitude of EEG is very small, and high amplification is necessary to obtain observable EEG. So, sometimes electro-magnetic noise and motion of subject (same as motion of electrodes) is the cause of EEG artifact. We suppose that most of the artifact of EEG under exercising will be concerned with the motion of subject, and the motion will be independent of EEG. In order to discriminate between EEG and noise from EEG under exercising, method of an algorithm that we designed is experimentally used in our EEG measurement system. In this paper, we will talk about this system.

II. Methodology

II-I System hardware

Fig.1 shows a block diagram of our measurement system. Our system consists of a EEG amplifier, an acceleration sensor, a 16bit analog to digital converter and a personal computer. EEG amplifier amplifies EEG about 12,000 times, and this signal is converted to the digital value after high pass (0.5Hz) and low pass (40Hz) filtered. Electrodes for EEG measurement are set on left earlobe (common), frontal pole (positive), vertex(negative). And EEG was measured under this bipolar condition. The position of EEG electrodes is shown in Fig.2. An acceleration sensor senses the body movement that will cause artifact of EEG. This acceleration output is amplified and high pass (0.5Hz) filtered and then converted to the digital value for the personal computer. This acceleration data is used for the reference signal of artifact, and a personal computer discriminates between EEG and noise from measured EEG data with artifact by using algorithm that we designed. Fig.3 shows the EEG amplifier of the system. Fig.4 shows an acceleration sensor (star precision ACB302). Fig.5 shows the amplifier and filter unit for an acceleration sensor. Fig.6 shown power supply unit.

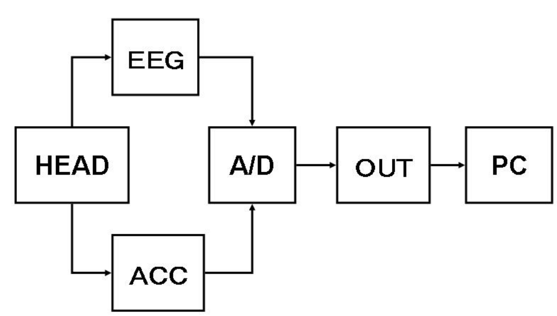


Fig1. Block diagram of our measurement system.

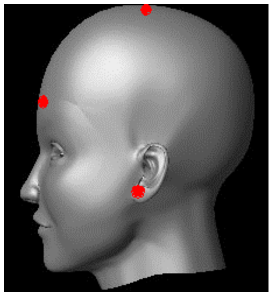


Fig2. Position of the EEG electrodes.

Fig3. EEG Amplier.

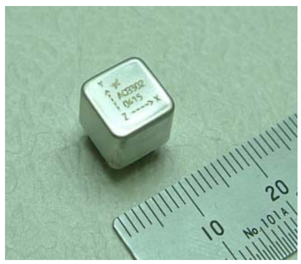


Fig4. Acceleration sensor.

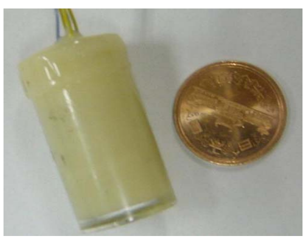


Fig5. Amplier sensor.

Fig6. power supply unit.

II-II System software

1. Adjustment Noise canceller

The method of the adjustment noise cancellation is used for the noise removal, and this algorithm was developed by us. This method removes the noise element from the signal that contains the noise, and is one of the basic filters in the signal conditioning that takes out only the interested signal. In this theory, the noise source is assumed X(t), and the signal that we want to know is assumed S(t). We suppose that S(t) and X(t) have no correlation. Where, we define D(t) that is the liner summation of S(t) and X(t). Therefore, D(t) is expressed the following equation.

$$D(t)=aS(t)+bX(t)$$

And we suppose that D(t) and X(t) are observable. In our system, we have to discriminate between S(t)(real EEG signal under exercising) and X(t)(artifact) from D(t)(EEG with artifact).

In our system, in order to obtain a coefficient "b", the variable "b'" is changed it's value step by step, and the correlation coefficient between D(t) and b'X(t) is calculated for each "b'". From this procedure, we can obtain the "b'" that bring the highest value of correlation coefficient between D(t) and b'X(t). We regard this "b'" as the coefficient "b". And then interested signal S(t) is obtained. Our algorithm is shown in Fig.7.

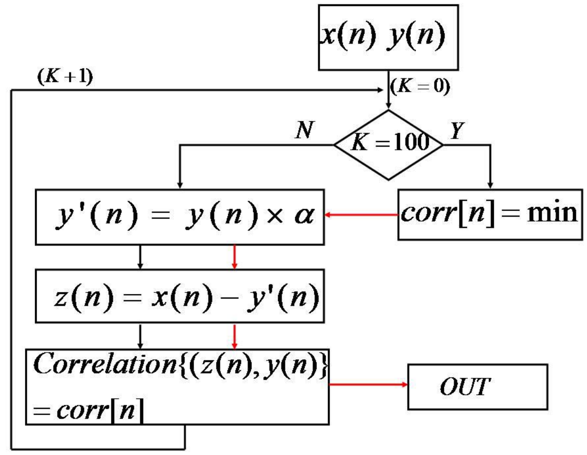


Fig7. algorithm.

III. Experiment

We suppose that the majority of the EEG artifact under exercising is the acceleration of the body(especially subject's head).

Five normal subjects ware tested with our noise reduction system. Electrodes and an acceleration sensor were set on their head. At first, EEG without exercising was measured for each subject. And then EEG and the acceleration under jogging on the treadmill were measured simultaneously.

And we applied EEG noise reduction system by using algorithm that we designed to the measured EEG.

Fig8 a). shows a subject under experiment. And Fig.8 b) shows a treadmill.

a) subject under experiment. *B) treadmill.*

Fig.8 Experiment scenery.

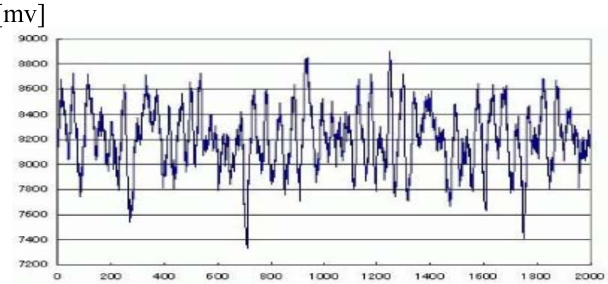
V. Result

Fig.9 is one example of measured EEG under rest state. Fig.9 a) is the wave form of EEG in time domain, and b) is the power spectrum of EEG. We can know characteristics of normal EEG from Fig.9. Fig.10 a) shows the measured acceleration signal, and b) shows the EEG with artifact. and c) and d) is the power spectrum of each output. These two signals (EEG with artifact and acceleration signal) were inputted to our artifact reduction system. Fig.11 shows the result of processing with our system. This wave form is similar to Fig.9 a). However, we cannot see whether this signal is the EEG or not.

So, the power spectrum of each EEG data (Fig.9(b) and Fig11(b)) were calculated.

However sometimes the acceleration data and brain wave data becomes no correlation by the experimental environment. It is thought that there are some delay time between the acceleration data and the EEG under exercising. Then, in order to cancel this delay, we estimated the delay time by the algorithm shown in Fig12. Using this algorithm, the delay time was obtained and time base of measured data was corrected. And then the noise was removed by using the algorithm that had been designed afterwards. Fig.13 a) shows the processing result using time base correction. And Fig.13 b) shows the power spectrum of the processing result using time base correction. The power spectrum of Fig.11 is approximately same as the power spectrum of normal EEG(Fig.9(b)). Therefore, we thing that the processed results will express the characteristics of read EEG and our method will work well.

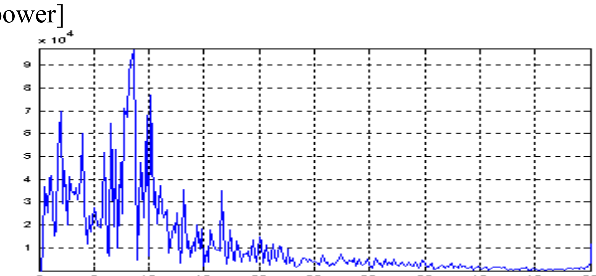
[mv]



[time]

a) Rest State.

[power]

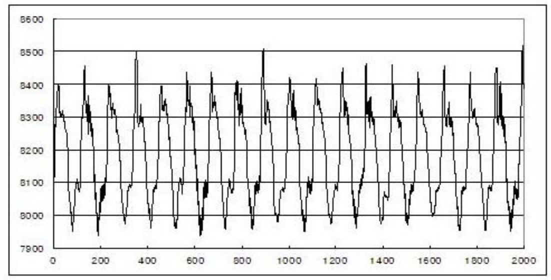


[Frequency]

b) Power spectrum（Rest State）

Fig. 9 One example of measured EEG under rest state.

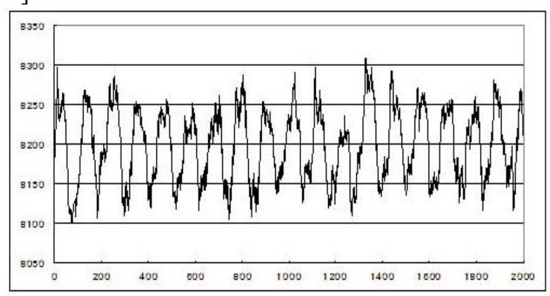
[mv]



[time]

a) Measure acceleration signal.

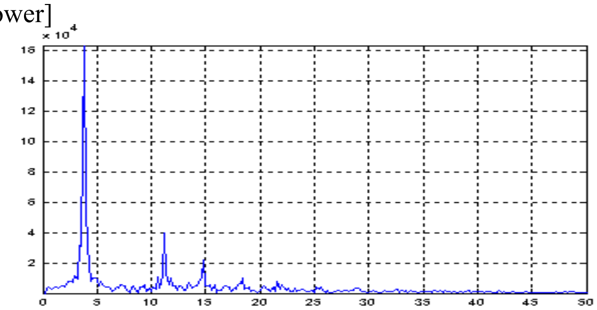
[mv]



[time]

b) EEG with artifact.

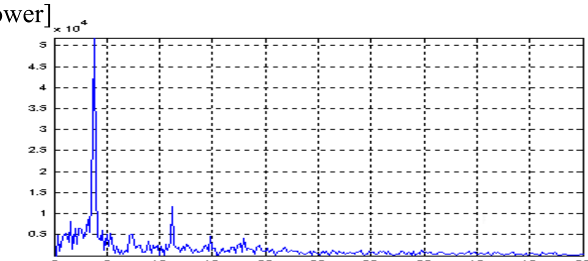
[power]



[Frequency]

c) Power spectrum (Measure acceleration signal).

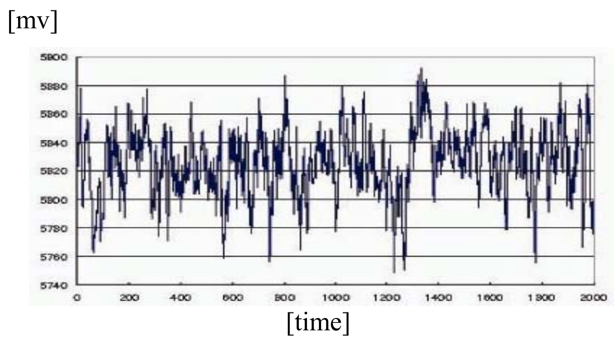
[power]



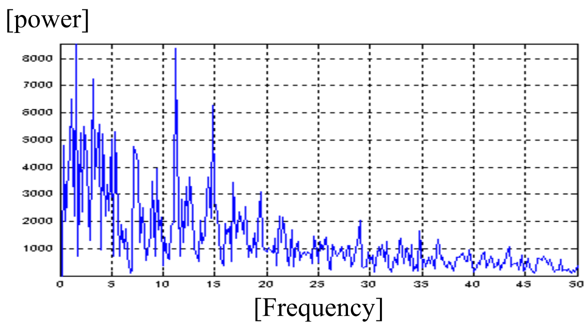
[Frequency]

d) Power spectrum (EEG with artifact).

Fig.10 Output Signal.



a) Processed signal.



b) Power spectrum (Processing signal)
Fig.11 Processing result.

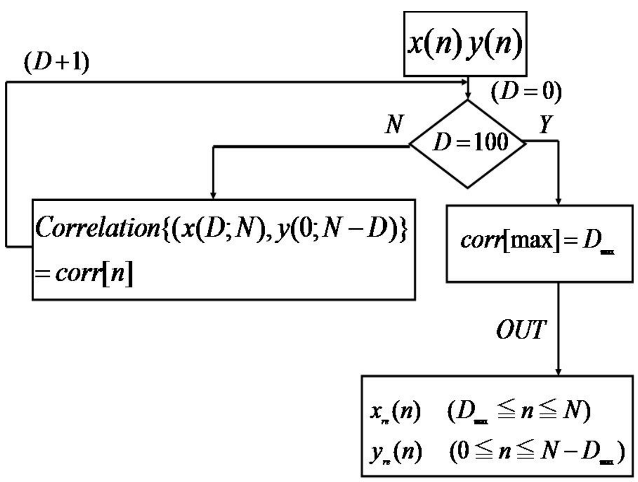
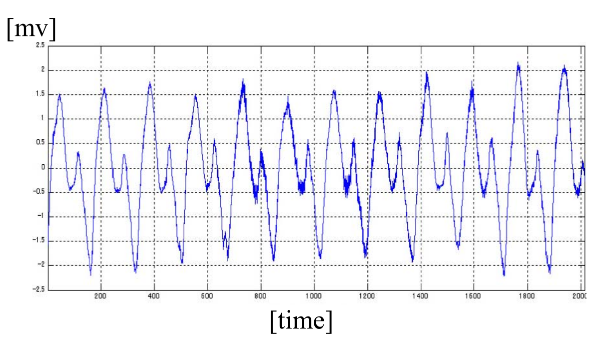
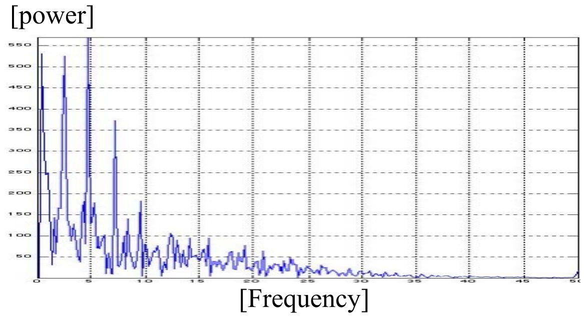


Fig.12 Delay algorithm.



a) Delay processing signal



b) Power spectrum (Delay analysis result)
Fig.13 Delay processing result

VI. Conclusion

In this paper, we talked about our EEG artifact reduction system. From experiments, our system can extract the EEG under exercising. Therefore, we have concluded that our new method will be extremely valuable to measure EEG under exercising. However, we cannot obtain the original EEG data from the data with artifact. In the future we need to look into this result more closely.

VII. Reference document

[I] Junya TANAKA, Mitsuhiro KIMURA, Naoya HOSAKA, Hiroyuki SAWAJI, Kenichi SAKAKURA, Kazushige MAGATANI "Development of the EEG measurement technique under exercising" proceeding of the International Federation for Medical & Biological Engineering VoL.12(2005)