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EEG Signal Processing in Japan+

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1. Introduction

The Electroencephalograph (EEG) analysis by computer has become more important since the advent of modern computer technology in the biomedical field. This is mainly because;

(1) The concern of EEG signals is rapidly growing up not only for the clinical use, but also in various fields related to the human brain activities, such as education, vocation, etc. More fundamental studies like psychiatric psychology (精神心理學)and neural physiology (神經生理學) are getting interested to use the EEG analysis techniques.

(2) Knowing the mechanism of brain is the final goal of biomedical research to reach and the large capacity, high performance, yet cheap computers will be able to proceed the research one step toward this goal.

The EEG research people in Japan belong either to the Japan Society of Medical Electronics and Biological Engineering (日本ME學會) or the Japan Society of Electroencephalography and Electromyography (日本腦波・筋電圖學會). Activites of Japanese EEG study people has been fairly big. In the 24th Annual Conference of the Japan Society of Medical Electronics and Biological Engineering, Sapporo, 3-5 July, 1985, about 30 papers were presented Recent annual convention of the latter society held in Fukushima, Nov. 18-20, 1985, 432 papers were presented Also, in the 11th International Congress of Electroencephalography and Clinical Neurophysiology, held in London, August 25-30, 1985 about 170 of the total of 1,300 registrants were Japanese delegates These figure out the Japanese EEG group activities.

The EEG signals, either spontaneous or evoked, are typical biological signals, and exhibit non-stationary characteristics in every respects. Therefore, we have to make considerable assumptions before processing the signals. If we treat signals deterministically, as is the case of synchronous averaging of evoked potentials, the number of data for addition is limited because of adaptation or fatigue of the subjects. If we treat the data sta tistically, the test for normal distribution is necessary. Personal difference must also be taken into account.

2. Spontaneous EEG Processing

Although the conventional multichannel paper recording of EEG are widely used in the routine work of clinical diagnosis, a trend to replace it to the computer processing is growing gradually. The reading of EEG record by doctor's needs the skill and experiences, but naturally depends on the doctor's subjective evaluation. And, training of primary

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care doctors to read the EEG is very difficult Therefore, the needs of objective and quantitative processing by computer is increasing.

Both time-domain and frequency-domain analyses are important. Template matching or matched filter technique is often used to detect the spike waves associated with epilepsy. Because of rare occurrence in the long time course of observation, long-term recording with fast playback analysis is essential. Specially designed portable recorder or an unobstructed wireless system is used for this purpose.

A government sponsored project to develop the early detection system of neural disorder for the new born or the infants. This system is basically a computerizeds sleep polygraphy, and automatically analyze the sleep stages continuously for more than 10 hours. It is expected that this system will improve the physician overload and contribute to the chil dren's mental health, by preventing from the various emotional disorders (情緒障害) which may realize after grown up.

The power spectrum of EEG, using Fourier transform, maximum entropy method and other orthogonal transform methods, gives us reasonable information in many cases, such as:

1. good correlation between rich alpha state and wake-up state,
2. objective monitoring of medication effect.
3. variation of spectrum with age in pediatrics(小兒科),
4. correlation between cerebral blood flow and the power spectrum,
5. power spectra predominance and laterality of brain hemispheres.

3. Processing of Evoked Potentials and Event Related Potentials

The research on evoked potentials and event related potentials have become remarkable during these ten years, as these potentials include more informations than these of ongoing EEG, can be extracted with proper paradigms. This is primarily due to the advancement of instrumentation technique utilizing popular micro-computers. Commercial products for evoked potential processing are also available in Japan.

There are problems in processing EP and/or ERP signals. For the EP processing originally, the mean addition or the averaging method has been widely used to enhance the evoked signals in the on-going EEG. This is successful specifically in processing the short latency EP s, such as the brain stem response. The auditory brain stem response (ABR) is useful to detect lesions in the brain, and has been studied by many people. However, the full identification of fast waves(Ⅰ～Ⅶ) and overlapped medium latency response needed new techniques. Further studies on stimulus click itself, periodic repetition or random repetition, location of electrodes, digital filtering of the responses, etc. are required. For longer latency signals the averaging is not effective due to jitter and changes in evoked signal itself during the long examination time. The template matching enables to detect the jitter of latencies, and to average responses with readjusted latencies. This is effective to some extent but not enough.

Thus, the trend of signal processing is moving from the averaging method to the statistical method. In particular, the analysis of the event related potentials(ERP) is based on the comparison between two groups of data, the discriminant analyss can be applied widely. As an example, the VEP data group, one is associated with character cognitive

process and the other without cognition, are discriminated by the power spectral components or the principal component coefficients, and proved to identify the latency of cognition.

4. Two-Dimensional Display and Dynamic Topography of EEG Data

The image processing technology is now popularized in the medical field. As the large capacity semiconductor memories are available the multi-channel EEG data are conveniently displayed on the CRT screen. The density of the screen corresponds to the average response, a component of power spectra, etc. The moment to moment spectra or the averaged intensities can be displayed like a movie, and these type of "dynamic topography" is appreciated in the clinical field.

5. New Approach

(1) Magnetoencephalography

Measurement of very weak magnetic fields are now possible using SQUID (superconductive quantum interference device). Some researchers are applying it in the encephalography with promising results. The two-dimensional mapping of the current sources are able to focus the location of epilepsy origin. This technique will be applied in the encephalography study in general, with a big merit of that we do not need the reference electrode.

(2) Intraoperation Monitoring

Not only the coventional polygraphy, the dynamic topography of brain state is strongly exqedted in brain surgery. To realize this, signal processing on the real time base is required. It may be possible with the present state of art, and further study to clear the specifications should be promoted.

(3) Future Problems

The study ofBrain is really attractive, because of its complexity far beyond of reach by human intelligence. It is intersting to remind that the human intelligent activities are done by the brain, of which the human knows very little. Biomedical engineering should find out some breakthrough toward understanding of its own brain, and it is believed that the signal processing technique may be the key to do so.