Analysis of pathological tremors using the autoregression model *

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Abstract—The usefulness of analysis of acceleration data using an autoregression model (AR) for differential diagnosis of Parkinson’s disease and other diseases with tremors was investigated. The order of the AR model used in this study was 7, in accordance with Akaike’s final prediction error criterion. The subjects included 19 patients with Parkinson’s disease; 21 patients with essential tremor, which mainly appears in old people, as well as Parkinson’s disease; and 13 healthy old people as a control group. The results of analysis of acceleration data showed that the first prediction coefficient, just as the main tremor frequency, was a useful parameter for differentiating patients in the Parkinson’s disease patient group and essential tremor patient group. The seventh prediction coefficient was found to be a useful parameter for distinguishing pathological tremors observed in Parkinson’s disease and essential tremor disease from physiological tremors observed in healthy people. Although the usefulness of other prediction coefficients for differential diagnosis of Parkinson’s disease and other diseases with tremors has not yet been clarified, the results of this study showed that information obtained from AR model parameters in addition to information on main tremor frequency is useful for the diagnosis of Parkinson’s disease.

Key words: Autoregression model; Parkinsonism tremor; essential tremor; pathological tremor.

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1. INTRODUCTION

A tremor is a shivering in the body. Tremors in healthy people are called physiological tremors, while those that appear as a symptom of a disease are called pathological tremors. A disease in which pathological tremors occur as a cardinal symptom is called a tremor disease. In this study, we focused on Parkinson’s disease, one of the so-called tremor diseases. The four main symptoms of Parkinson’s disease are tremors, muscular rigidity, bradykinesia and postural instability – gait difficulty; the probability of single or multiple symptoms appearing is over 70% [1]. Tremors, with a frequency of 4–6 Hz at rest, occur most frequently as the initial symptom and are considered to be important for the diagnosis of Parkinson’s disease [2].

It is possible to delay the progress of symptoms of Parkinson’s disease by treatment in the early stage [1] with effective drugs such as L-dopa [3]. However, early diagnosis of Parkinson’s disease is difficult because the symptoms progress slowly. Parkinson’s disease is therefore often missed or misdiagnosed as another disease that has similar symptoms.

We have carried out quantitative measurements and analyses of tremors to try to differentiate the characteristics of tremors in early-stage Parkinson’s disease and those in other diseases with symptoms similar to those of Parkinson’s disease [4–6]. We have determined the main frequency (main tremor frequency) of tremors in Parkinson’s disease using fast Fourier transform (FFT), and this frequency can be used as an index to differentiate Parkinson’s disease and the other similar tremor diseases. However, when only the main tremor frequency is used, Parkinson’s disease is sometimes difficult to differentiate from other diseases because it is not possible to sufficiently extract features of the tremor in some cases using only the main tremor frequency due to the existence of multiple peaks in the power spectrum of the tremor.

In this study, an autoregression (AR) model was therefore used to try to extract the general features of the tremor. The AR model is used for analyzing signals such as brain waves and physiological tremors, and it expresses features of signals by a set of parameters [7, 8]. We obtained these parameters and compared them with the main tremor frequency. The results showed that the AR model is an appropriate model for determining general features of tremors in Parkinson’s disease.

2. MEASUREMENT SYSTEM

Figure 1 shows a schematic diagram of the measurement system used in this study. In this system, the subject sits on a chair with his/her elbows on a table in front of the chair, keeping the angle of each forearm at about 45° from the plumb line. An accelerometer (9G320S; NEC San-ei) is fixed to the bases of both thumbs with tape. The acceleration signal is amplified by a charge amplifier (AG2101; NEC San-ei) and recorded by a digital oscillograph recorder (Omniace RT3104; NEC San-ei). The sampling period of the digital oscillograph recorder was 20 ms ($\Delta t = 20$ ms).