17-69

Linear and Nonlinear Analysis Methods for Bio-Signal

Azian Azamimi (Tokushima University)
Yoshifumi Nishio (Tokushima University)

1 Introduction

Bio signal analysis becomes a hot research topic recently, due to its importance demands for clinical and biomedical application. Bio signal means a collective electrical signal acquired from any organ that represents a physical variable of interest like EMG signals, EEG signals or finger pulse signals. Bio signals are usually exhibit complex behaviour with nonlinear dynamic properties and considering this, the nonlinear dynamics theory maybe a better approach than traditional linear methods in characterizing the complex nature of bio signals [1].

In this study, we analyze the finger pulse signal using both linear and nonlinear characteristic measures like Fourier transform (FFT) and Lyapunov spectrum. We measure the finger pulse signal for 19 minutes with two different conditions (data for 1 person). Then, we compare the characteristic extracted by both linear and nonlinear methods.

2 FFT and Lyapunov Spectrum

As you may know, a Fast Fourier transform (FFT) is an efficient algorithm to compute the discrete Fourier transform (DFT) and its inverse. FFTs are of great importance to a wide variety of applications, from digital signal processing and solving partial differential equations to algorithms for quickly multiplying large integers. In this case, we use FFT method to carry out the signal processing of finger pulse signal as linear analysis method.

As for nonlinear analysis method, we use the Lyapunov Spectrum instead. Lyapunov Exponent (λ) is a quantitative measure of the sensitive dependence on the initial conditions. It defines the average rate of divergence of two neighbouring trajectories. Therefore, the existence of a positive λ for almost all initial conditions in a bounded dynamical system is widely used definition of deterministic chaos. To discriminate between chaotic dynamics and periodic signals Lyapunov Exponent (λ) are often used.

3 Simulation Results

Figure 1 shows the time series data of finger pulse signal for 19 minutes with two different situations. In the beginning of the experiment, the finger pulse is measured in relax condition. Therefore, in the end of the experiment, the finger pulse is measured in the condition where we have to do some mathematics calculation. Figure 2 and figure 3 show the analysis result of FFT method and Lyapunov method respectively.

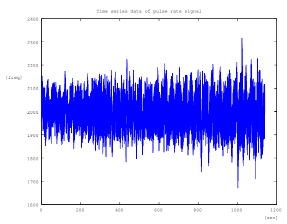
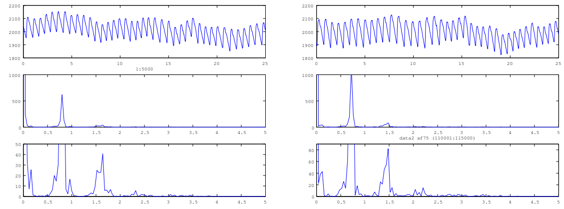
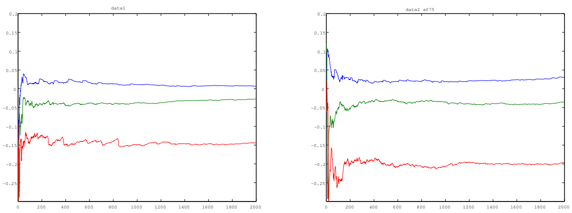


Figure 1: Time series data of finger pulse signal.



(a) (b)

Figure 2: Result of FFT method. (a) Relax. (b) Concentrate.



(a) (b)

Figure 3: Result of Lyapunov Spectrum method. (a) Relax. (b) Concentrate.

Relax	Concentrate
0.0126	0.0331

Table 1 shows the final value of Lyapunov exponent for relax and concentrate conditions. We found that it is hard to extract the different characteristic of finger pulse signal using the linear method. But on the other hand, we found the different of lambda value of two different conditions by using the nonlinear methods. In the relax condition, λ value is near to 0, showing that the orbits are on a stable attractor but in concentrate condition, λ value is a positive exponent showing that the orbits are on a chaotic attractor. This result show that the signal becomes less complex when the person is in relax condition.

4 Conclusions

In this study, we had confirmed that the nonlinear analysis approach is more suitable used in characterizing the bio signal. In the future, we will measure finger pulse signal of more persons with other different situations and calculate the average of numerical value. This is the first step for developing nonlinear analysis methods of bio-signal.

References

[1] K. Natarajan, R. Acharya, F. Alias et al., "Nonlinear analysis of EEG signals at different mental states," BioMedical Engineering OnLine, 2004.