CHAOS DYNAMICAL ANALYSIS OF EEG DATA

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We carried out an analysis of electroencepharogram (EEG) of human α-rhythm in the viewpoint of chaos dynamics. For the analysis, we use the method which utilize an three-dimensional attractor constructed by embedding procedure of three sets of time series data [1]. The chaos dynamical analysis is performed by using return maps on the Poincaré-like section which intersects the constructed attractor obtained by the embedding. The briefscheme of the procedure is shown in Fig.1.

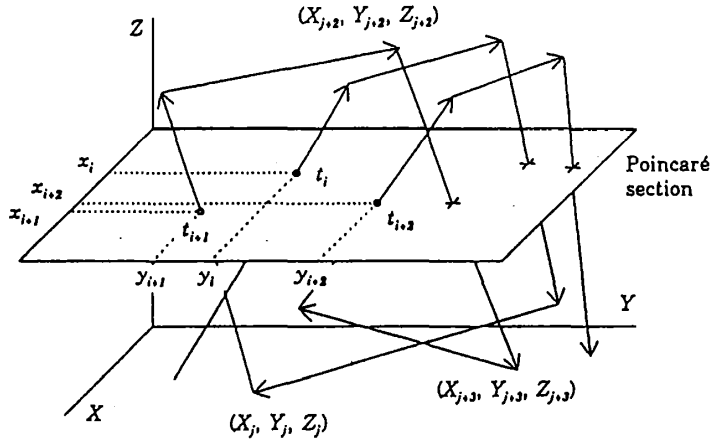

Fig.1 Schematic Representation of Poincaré-like Section
The trajectory which temporally developed in three-dimensional space of data coordinates (shown by long arrows) and the plane of Poincaré-like section with a fixed Z value are shown. Intersection points $(x_i, y_i), (x_{i+1}, y_{i+1}), \ldots$, and intersection time $t_i, t_{i+1}, \ldots$ are indicated. The intersection points are classified with respect to intersecting directions of the trajectory, i.e., upward (o) and downward (+) directions.

Three sets of data $\{X_i\}_n$, $\{Y_i\}_n$, $\{Z_i\}_n$ from an embedded attractor and then they yield intersection points $\{x_i\}_m$, $\{y_i\}_m$ and intersection time $\{t_i\}_m$ on the Poincaré-like section at $Z=Z^*$ which is parallel to XY-plane. By use of intersection points and intersection time, one can make return maps of intersection points and interval time of intersectioning. If data points obey a certain mechanics, it will be expected that return maps show fine structures such as a one-dimensional mapping. We therefore use this method.

The EEG data used in the present analysis are shown in Fig.2. Channels number 1, 2, 3 denote recording sites of EEG at the head, namely, 1ch is the left side of sb's eyes, 2ch left back of head, and 3ch left side of head, respectively. α-rhythm is clearly appeared on the 2ch recording.

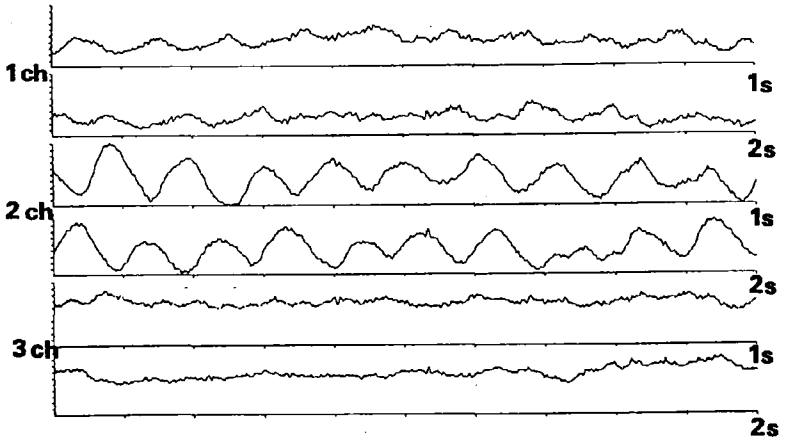

Fig.2 EEG Data Used in the Present Analysis
Sampring intervals at the recording is 1ms. Total number of data points is 2000, i.e., total recording time is 2s. Amplitude of EEG is in the range of $\pm 50 \mu V$.

The constructed attractor by embedding these three channels' data is shown in Fig.3. The return maps of intersection points (Fig.3 a,b) don't have any fine structure. It is difficult to see that EEG is the result of a certain chaotic dynamics. We however expect that the return maps have a certain kind of structure. The structure which will be obtained may lie in several-dimensional space. This is expected to be forthcoming work.

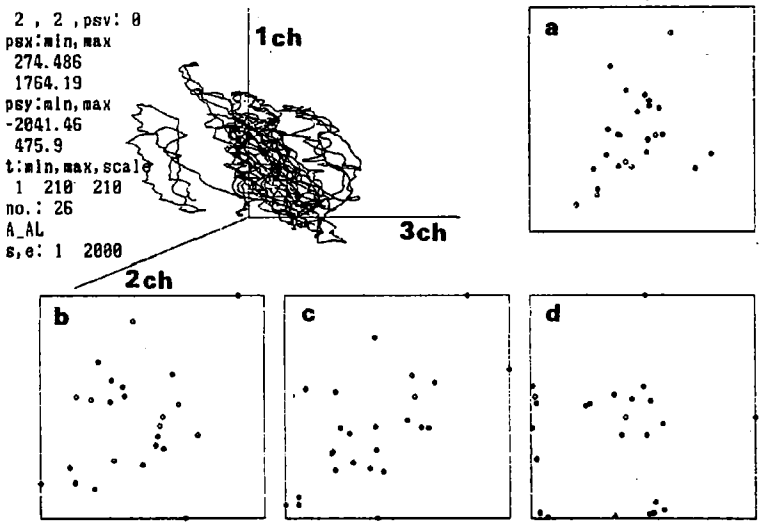

Fig.3 Constructed Attractor of EEG and Return Maps
a: Poincaré-like section at Z=0, b: return map of intersection points of 2ch data, c: return map of intersection points of 3ch data, d: return map of interval time to intersect the Poincare-like section. Figures are depicted in arbitrary scale.

References

[1] T. Inaba, Y. Nagai, and H. Wako, "Dynamic relationships among economic variables examined by the embedding method.", Dynamical Systems and Chaos, ed. K. Shiraiwa et al, World Scientific, Singapore, (1995) Vol.1 pp.381-388.

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