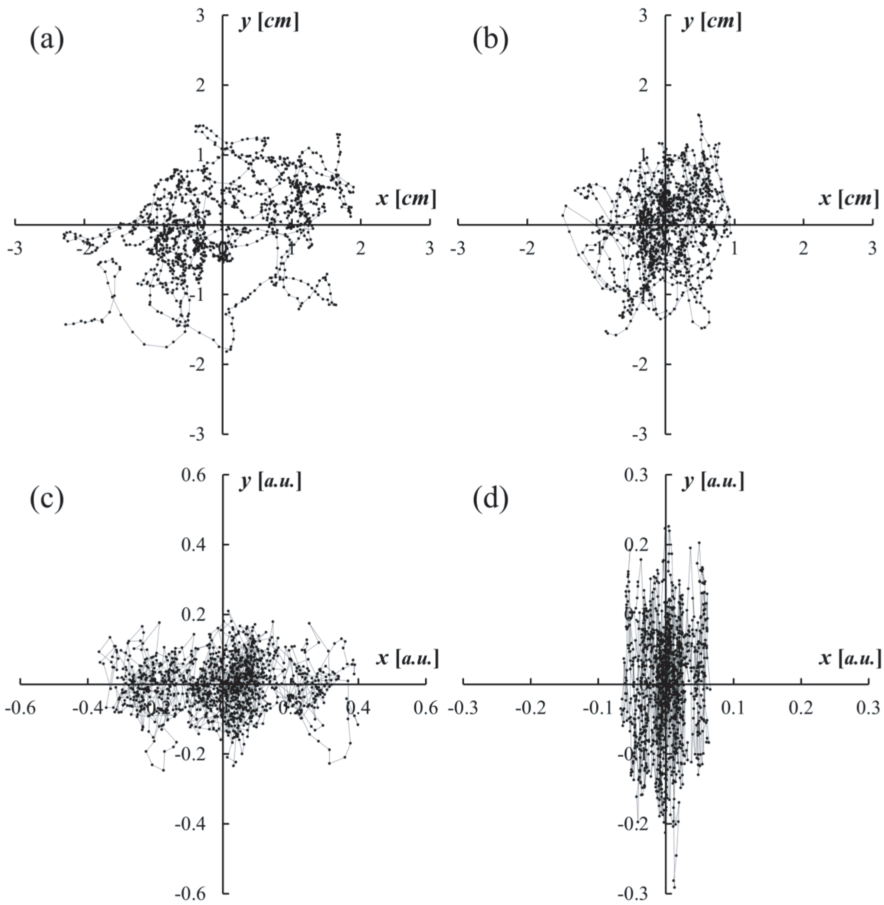

Fig. 2. Typical stabilograms: for a young female (a), for an elderly female (b), obtained from numerical solutions for the stabilogram (a) of a young subject (c), and obtained from numerical solutions for the stabilogram (b) of an elderly subject (d).

those using prescribed drugs, and those who may have had any otorhinolaryngologic or neurological disease in the past (except for conductive hearing impairment, which is commonly found in the elderly). This study was approved by the Research Ethics Committee of the Graduate School of Information Science, Nagoya University.

Stabilometry was conducted on subjects gazing at a visual target 2 m ahead. They stood on the stabilometer with a Romberg posture. The motion process of the body sway for each component is assumed not to be with anomalous diffusion but to be generated by Markov process. Also, components of the body sway are assumed to be independent [10]. A SDE was obtained from the time series data measured in this stabilometry as a mathematical model of the body sway for each component.

Through statistical processing, the mean of each stabilogram was first set to the original point O. Then, a histogram in each direction was obtained from a stabilogram. Next, a TAPF was estimated from a histogram by using the following polynomials: shown that it is necessary to extend the following nonlinear SDEs for a description of an individual body sway.

$$\hat{U}_x(x) = a_x x^4 + b_x x^3 + c_x x^2 + d_x x + const., \quad (5)$$

$$\hat{U}_y(y) = a_y y^4 + b_y y^3 + c_y y^2 + d_y y + const. \quad (6)$$

The TAPFs in each direction for each group were regressed through polynomials of degree four. Weak nonlinearity could be observed in the potential function, especially in the lateral direction of the young subjects. In general, the variance of a stabilogram depends on the TAPF with those several minimum values. Substituting Eqs. (5) and (6) into Eqs. (1) and (2), the SDEs

$$\frac{\partial x}{dt} = -\frac{\partial \hat{U}_x(x)}{\partial x} + \mu_x \omega_x(t), \quad (7)$$

$$\frac{\partial y}{dt} = -\frac{\partial \hat{U}_y(y)}{\partial y} + \mu_y \omega_y(t), \quad (8)$$

were finally determined as mathematical models of the body sway. Numerical solutions were obtained using the Runge-Kutta formula as the numerical calculus. The initial values of (x, y) were set to the original point O. In Eqs. (7) and (8), $\omega_x(t)$ and $\omega_y(t)$ are pseudorandom numbers (with mean $\pm$ standard deviation of 0 ± 1.0) produced by white Gaussian noise. The time step Δt was set for every 0.001 step, from 0.001 to 0.05. The noise amplitudes μ_x and μ_y were set for every 0.1 step, from 0.1 to 4. A numerical analysis was applied for 11,200 steps, and the first 10,000 steps were discarded owing to the dependence of the initial value.

4. Evaluation Methods of Numerical Solution

In previous research, numerical solutions were evaluated using the following method [16].