§ 35. Development of Root-Finding Method Based on Genetic Algorisms

Yagi, M., Furuya, A., Itoh, S.-I. (Kyushu Univ.)

Genetic algorithms (GAs) are derivative-free optimization methods based on the concepts of natural selection and evolutionary process. It finds significant applications in many areas. For examples, it is applied for the evolution of weighting function[1] of neural networks and is also applied for controlling chaos[2] . Here we are interested in the application of GA for root finding for the eigen function of the drift wave with maximum growth rate in huge parameter space. Also, the technique of controlling chaos via GA might be applicable for controlling plasma turbulence for the future.

Our strategy is as follows: in the first step of this research, we will start from the linear control method known as delayed feedback method[3] and apply this method to Duffing equation to control chaos as an example. Then in the next step, we will investigate nonlinear control method such as neural network and GA for it and evaluate the merit and demerit of these methods.

The Duffing equation with feedback term is given by

$$\frac{dx}{dt} = y$$

$$\frac{dy}{dt} = -ky - x^3 + B_0 + B_1 \cos t + A(y(t-\tau) - y(t))$$

The standard 4[th] order Runge-Kutta method is not applicable for this case since we must evaluate the time delay term $y(t-\tau)$ in each step. We adopt the 4[th] order Adams-Bashforth method in the predictor step and the 4[th] order Adams-Moulton method in the corrector step as the numerical integration scheme.

Figure 1 shows the time series data of $x(t)$ in the case with $k = 0.05, B_0 = 0.045, B_1 = 0.16, A = 0$. For these parameters, the chaotic behavior is observed in the time series data. Figure 2 shows the chaotic attractor[4] in $x - y$ phase space for these parameters.

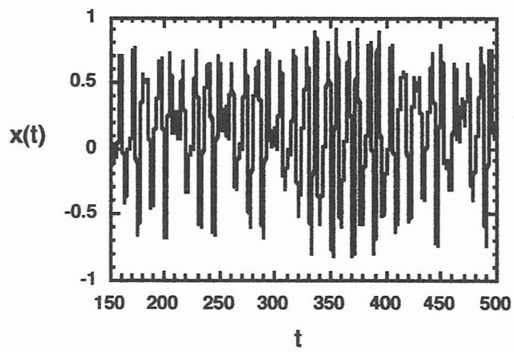

Fig.1. The time series data of $x(t)$ in the case with $k = 0.05, B_0 = 0.045, B_1 = 0.16, A = 0$.

Next, we try to control the chaos. Figure 3 shows the time series data of $x(t)$ in the case of $A = 0.4, \tau = 2\pi$. The other parameters are same as in Fig.1. The attractor in this case is shown in figure 4.

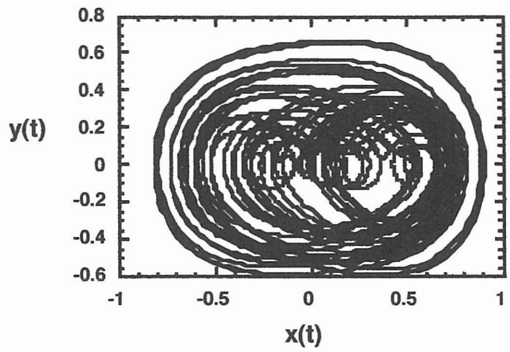

Fig.2. The chaotic attractor in $x - y$ phase space.

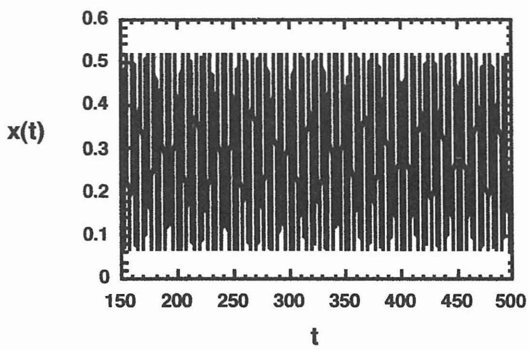

Fig.3. The time series data of $x(t)$ with the delayed feedback. The controlling parameters are chosen as $A = 0.4, \tau = 2\pi$.

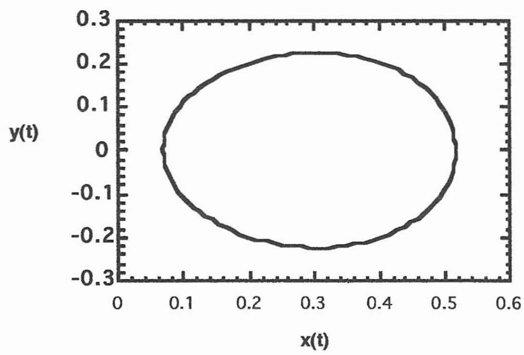

Fig.4. The corresponding attractor (limit cycle) to figure 3.

The control of chaos is successful in this case, however, to determine appropriate A, we need the trial. In addition to this demerit, it is unknown which limit cycle will be stabilized if there are several limit cycle orbits.

The nonlinear controlling method of chaos is now developing. We will compare the results with those by delayed feedback method.

References

1) D. Montana and L. Davis, in Proc. of International Joint Conf. on A.I., Morgan Kaufmann 1989.
2) E. Weeks and J. Burgess, Phys. Rev. E 56 1531 (1997).
3) K. Pyragas, Phys. Lett. A 170 421(1992).
4) Y. Ueda, The Road to Chaos, Aerial Press (1992).