International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 5 Issue 11 ǁ November. 2017 ǁ PP. 01-05

Surver on Nonlinear Dynamical Systems

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ABSTRACT: Chaos and chaos control are new theories and new fields of nonlinear dynamics. Chaotic motion is a complex irregular behavior produced by nonlinear dynamical systems, which is prevalent in various fields of nature. This paper introduces the development of chaos, the development of chaos and the development of chaos control, and summarizes the different strategies of chaos control. This paper introduces the idea, principle and characteristics of OGY method, introduces the adaptive control method, continuous feedback control method and neural network method, and puts forward some opinions on the possible difficulties in the future, and points out the application prospect and research direction of chaos control.

Keywords: Chaos,Chaoscontrol,Chaosproduction,Nonlinear Dynamical Systems

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Date of Submission: 01-11-2017 Date of acceptance: 09-11-2017

I. INTRODUCTION

In the second half of the twentieth century, nonlinear science developed vigorously. Since 1963, American meteorologist Lorenz discussed the chaos phenomenon, people on the law of chaos and its performance in various fields of natural science has been a rich understanding. The fact that chaos is widespread in nature and human society has been universally accepted, and how to apply the results of chaos research to human services has become one of the important subjects of nonlinear scientific development. Chaotic control becomes the key link of chaotic application due to the law and characteristics of chaos motion. At the same time, chaos control has a great research value in engineering technology and extremely attractive application prospect. Chaos control problem has aroused great concern of non-linear dynamic system and engineering control experts, which has become one of the hotspots of nonlinear scientific research.In this paper, the background of chaos and its commonly used control method are introduced for the characteristics of chaos. Especially in recent years, research results, and simply pointed out that chaos control the direction of future research.

1. The Generation Of Chaos

Chaos is a kind of motion form of nonlinear dynamical system under certain conditions, which is a stochastic phenomenon in deterministic system. Therefore, nonlinearity is a necessary condition for chaos. It is generally believed that when the system has the following numerical features.
1)The motion trajectory of the system is a strange attractor
2) The power spectrum of the system motion has the characteristic of superimposing the spikes on the continuum
3) There is at least one Lyapunov exponent in the system $\lambda>0$
2. 1 The Cycle Of Bifurcation Into The Chaotic Road

The periodic behavior of the system motion is an orderly state. Under certain conditions, the change of the parameters doubles the system orbit period, and the system will gradually lose the periodic behavior and enter the chaos.

2. 2 Bursts Of Chaotic Roads

Chaotic chaos refers to the time when the system changes from order to chaos. Under the condition of non-equilibrium nonlinearity, when the change of some parameters reaches a certain critical threshold, the time behavior of the system is suddenly and sometimes chaos, oscillation. When the parameters continue to change, the whole system will develop chaos from paroxysmal chaos. Paroxysmal chaos is first seen in the Lorenz model. It is a twin phenomenon caused by doubling bifurcation.

2. 3Ruelle - Takens Road

When the chaotic phenomenon occurs in the fluid system, its significant feature is the system at the same time there are a variety of frequency oscillation so the system due to some changes in the parameters of the system have different frequencies of oscillation coupled with each other, the system will produce a series of coupling The movement of the frequency leads to chaos. The process is as follows: With the change of the parameters, the system can enter the limit ring from the fixed point, and the bifurcation of the limit ring is the two-dimensional torus, and then the bifurcation to the three-dimensional torus again into the chaos. In short, in addition to the above three kinds of roads leading to chaos, there are quasi-periodic process, such as cutting the flow of brutal and other ways to produce chaos, scientists even come to "knot road chaos" conclusion.

II. THE DEFINITION AND CHARACTERISTICS OF CHAOS

3.1The Definition Of Chaos

The development of chaotic science has aroused the interest of various disciplines, but as scientific terms, chaos has not been universally recognized as the definition. Lorenz, known as the "father of chaos," points out that chaotic systems refer to a system that is inherently sensitive to initial conditions. Li Tianyan and J. A. Yorke in 1975, "the cycle of three means chaos" first proposed a modern scientific sense of chaos in the mathematical definition. But the drawback of Li - Yorke 's definition is that the Legeger measure of the set in the definition is likely to be zero, that is, the chaos is unobservable at this time, and the people are interested in the observable situation. R. L. Devney gave another definition of chaos in 1989.Let X be a measure of space, a continuous mapping f: $X \rightarrow X$ said X on the chaos

1) f is topologically transmitted;
2) The periodic point of f is dense in X;
3) f has sensitivity to initial conditions.

In addition to the above definition of chaos, there are definitions such as Smale horseshoe, crossed homestead, topological blending, and symbolic dynamical systems.

3. 2Chaotic Characteristics

1)Very sensitive to the initial value;
2) the system has a state of ergodicity;
3) have regular ingredients.

III. CHAOS CONTROL OBJECTIVES AND METHODS

Chaos control method has two kinds, one is through the appropriate strategy, methods and ways to effectively inhibit the chaos behavior, so that the Lyapunov index down and then eliminate the chaos. The second is to choose a track with the desired behavior as a control target.In general, infinitely many unstable periodic trajectories in chaotic attractors are often used as the preferred target, and the purpose is to convert the chaotic motion trajectory of the system to the desired periodic orbit. Different control strategies must follow the principle that the design of the control law must minimize the original system and thus minimize the impact on the original system.

4.1 OGY Method

In 1990, Ot.TE,Grebog.IC,Yorke. J.A proposed a parameter disturbance method for controlling chaos, referred to as OGY control method. The main idea of the OGY control method is to stabilize the infinitely many unstable orbits in the chaotic attractor by adding tiny perturbations to some systems.

The OGY method yields chaos that can be used to control this important new conclusion in a concise way. While taking full advantage of the characteristics of chaotic movement. First, the OGY chaos control does not require the exact dynamic mechanism of the known chaotic system. Secondly, the OGY control always minimizes the control cost and minimizes the control cost, and keeps the nature of the original system from external control. Features. Third, the chaotic motion-rich periodic orbit makes the selection of chaotic control target state great flexibility, not only suppress chaos, but also use chaos. OGY control has many advantages, but there are some shortcomings, on the one hand, OGY control based on the target area of the linear analysis of the neighborhood, it always has a small window, only when the chaotic orbit into the scheduled window mechanism to start, It takes time. On the other hand, since the control signal has a discrete pulse form and can not change with the continuous orbit in time, it often leads to burst out of control in the presence of a noise environment, especially with OGY control to stabilize the long-period orbit.

4.2 Continuous Feedback Control Method

Although the OGY method and its improved method effectively control the chaos so that it is widely used in the fields of mechanics, optics and environmental science, but because it must obtain the Poincare section, and need to determine the required unstable periodic orbit The eigenvalues and eigenvectors of the moving points, which make its application subject to certain restrictions. On the basis of the OGY control method, the German scientist K. Pyragas proposed in 1993 the external feedback control method and the delayed feedback control method. These two methods can achieve continuous control of the chaotic attractor, so that the unstable cycle tends to be stable.The principle is shown in Figure 1 and Figure 2.

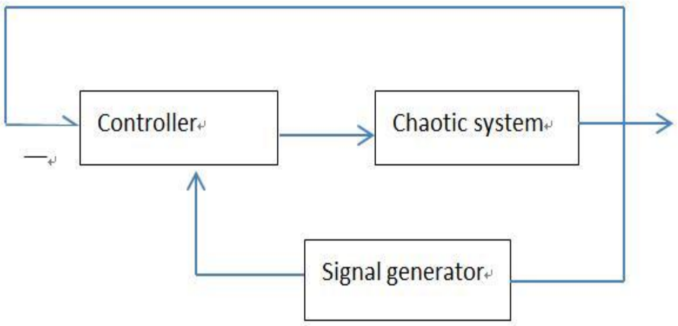

Figure 1

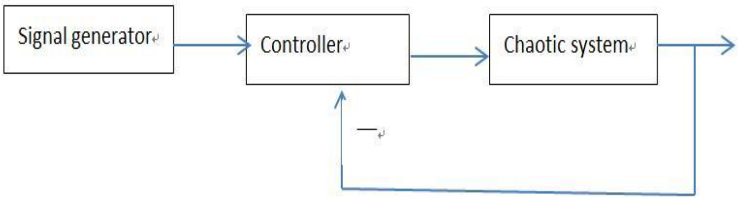

Figure 2

4.2.1 External Force Feedback Control Method

The external force feedback control is characterized by a forced signal excitation system, and compared with the response signal, given the control signal to the system perturbation. The premise is that there are controllable infinitely many periodic and aperiodic orbits, requiring the presence of chaotic singular attractors in the perturbation system.

Considering the dynamical system of nonlinear ordinary differential equations, for the sake of simplicity, it is considered that perturbation control only disturbs the response variables of the first equation:

$$\begin{cases} \frac{dy}{dt} = P(y, x) + F(t) \\ \frac{dx}{dt} = P(y, x) \end{cases} \quad (1)$$

Where y is the response variable and x is the other unpredictable or unrelated amount. There are many different periodic signals in the chaotic attractor range, corresponding to different stable periodic orbits. In order to achieve the purpose of controlling chaos, it is necessary to design an external signal generator so that the resulting signal is equal to or proportional to y i (t), in which a chaotic orbit (periodic signal) y i (t) is chosen. And its difference with the response signal y (t):

$$F(t) = K[y_i(t) - y(t)] = K D(t)$$

As a perturbation control signal, where K is an experimentally adjustable perturbation weighting factor, called a control factor. Appropriate adjustment K can achieve the purpose of controlling chaos.

4.22Delayed Feedback Control Method

The delay feedback control method uses the system to respond to a part of the signal and after time delay, and then subtract from the original response signal, the difference as a control signal feedback to the system. The specific perturbation control signal is:

$$F(t) = K[y(t-\tau) - y(t)] = K D(t)$$

Where τ is the delay time, the same time as the unstable period is selected. By adjusting K and D (t), the same result of the external force feedback control method can be achieved, and the chaotic motion can be controlled.

4.3 Adaptive Control Method

The adaptive control method is proposed by Hubermen, Sinha et al., Which adjusts some parameters of the system through the difference between the target response and the actual response, which stabilizes the actual response of the system to the target response. Consider the single parameter adaptive system equation:

$$X_{n+1} = F(\mathrm{x}_n, \mathrm{k}_n)$$

Among them, for the actual output, for the control parameters, the adaptive control of the parameters of the standard form is:

$$\mathrm{k}_{n+1} = \mathrm{k}_n - \varepsilon G(e_n, de_{n+1} / dk_n)$$

Where ε is the intensity of the adaptive control mechanism, is a continuously adjustable parameter, $G(e_n, de_{n+1} / dk_n)$ is a function of error e_n and continuous derivative de_{n+1} / dk_n, where $e_{n+1} = x_{n+1} - d_{n+1}$, where d_n is the desired fixed point.

Adopt adaptive mechanism of direct quantitative analysis, then:

$$\mathrm{k}_{n+1} = \mathrm{k}_n - \varepsilon(\mathrm{x}_n - \mathrm{d}_n).\mathrm{sgn}(\mathrm{dF}(\mathrm{x}_n / \mathrm{k}_n) / \mathrm{dk}_n)$$

When the function has the quadratic maximum and satisfies $\mathrm{sgn}(\mathrm{dF}(\mathrm{x}_n / \mathrm{k}_n) / \mathrm{dk}_n)$, the system strength ε = 0 increases the control parameter k, and the system can enter the chaos by the periodic bifurcation sequence.

4.4 Intelligent Control Method

Chaotic system and the complexity of control, so that people naturally consider the introduction of intelligent methods into chaos control, the use of fuzzy logic controller and neural network on the chaotic system modeling and control has done some exploration.

4.4.1 Neural Network Method

Artificial neural network has been proved to have the characteristics of arbitrary approximation to nonlinear system. Combining artificial neural network with chaotic system, some scholars have proposed some control methods of chaotic system based on artificial neural network, and the chaos in chaos system Behavior to implement effective control. Tan Wen et al proposed a chaotic motion based on feed forward back propagation neural network to control nonlinear systems. Based on the OGY method, the improved BP learning algorithm combined with the BP algorithm of the variable learning rate and the BP algorithm with variable learning rate is used to stabilize the attractor embedded in the unstable chaotic orbit to return to the stable point. Alsing uses a back propagation BP network to stabilize the unstable periodic orbits of embedded chaotic systems. Chen - Teng Lin proposed a GA - based re - excitation learning neural network controller, which does not need to know the equilibrium point of chaotic system, and does not need the output data of the system to stabilize the system to high - cycle orbit.

4.42 Fuzzy Control

For systems with uncertain systems or mathematical models that are overly complex, the use of fuzzy control strategies tends to be better than the control of many conventional controls. Chaotic system as a complex nonlinear system, the application of fuzzy control strategy is also a good attempt. Liang Chen et al. Used chaotic time series to predict and control unknown chaotic systems. During the chaos prediction, the fuzzy membership function and the least squares check rule are used, and the system behavior is predicted by using the input and output data of the system. In the controller design stage, the stability criterion of Li Ya strike is the main Design principles, change the strategy at the same time to achieve the system of forecasting and control. The control experiment of Hua circuit shows that the system control allows the perturbation of the parameters to be large, and the system can be fast and stable.

IV. CONCLUSION

In this paper, the main results of the current chaos control are analyzed in detail. So far, many studies have been made on chaos control research, but chaos control is still a new scientific frontier. Many systems theory and effective methods are still To be developed.

1) Mathematical Basis of Chaos Control Theory. To seek new mathematical tools and analytical methods , based on mathematical and computer theory for extensive research, to provide control of the selection of theoretical guidance and regular conclusions.

2) Engineering realization of chaos control theory. A large number of simulation results have proved that the chaos

control theory in the engineering system in the effectiveness, but to truly achieve its extensive engineering applications, still need a lot of in-depth research and testing, absorbing cross-scientific results, the introduction of new research tools to form a real practical Of the research results.

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*ZhiWen Dai. "Surver on Nonlinear Dynamical Systems." International Journal of Research in Engineering and Science (IJRES), vol. 05, no. 11, 2017, pp. 01-05