

Research Article

Dynamical Systems of Differential Equations Based on Information Technology: Effects of Integral Step Size on Bifurcation and Chaos Control of Discrete Hindmarsh–Rose Models

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Based on the differential equation dynamical system of information technology, this article analyzes how the integral step affects the bifurcation and chaos control of the discrete Hindmarsh–Rose model and its effect. By introducing the advantages of information technology in information management and information processing to the application of the differential equation dynamical system, the stability of the differential equation dynamical system model can be guaranteed. The integration step size is an important factor that affects the accuracy of the study results, and therefore, this paper understands how it affects the 3D discrete Hindmarsh–Rose model by choosing the appropriate step size.

1. Introduction

As a new technology, information technology (IT) has unique advantages in information management and information processing. It is a general description of various technologies, including computers, communications, sensors, and intelligence. The application and application field of information technology are very broad. It can design and develop software, and install information system to identify, transmit, and process information and data through computer computing and intelligent communication technology. It has broad market development prospects. As an important kind of equation in modern mathematics, differential equations can provide reference for researchers in solving practical problems in various fields. Dynamical systems of differential equations have abundant application information and broad research prospects in geography, mathematics, astronomy, and pedagogy. Therefore, the study of the differential equation dynamical system not only has a strong theoretical value, but also has strong practical

significance. When information technology is combined with the research prospect of the differential equation dynamical system, it is very beneficial to the accuracy of the model construction of the differential equation dynamical system [1].

In 1952, Alan Lloyd and Andrew Huxley proposed a 3D model to study the discrete processes associated with the potential for conflict in the giant octopus axis. Many scholars have introduced various types of theories and methods to improve this model in an attempt to reduce its complexity and to obtain a simplified model without changing the model dynamics. The 3D time dispersion is carried out step by step according to the swamp integral method, and the local and global branches of the Roth model have serious consequences. By changing the integration step, the system exhibits complex dynamic behavior [2].

In this article, the influence of integral step size on bifurcation and chaos control of the discrete Hindmarsh–Rose model is studied under the premise of the

differential equation dynamical system based on information technology, and the theoretical and practical experience obtained is expected to provide help for subsequent workers to understand bifurcation and chaos control of the discrete Hindmarsh–Rose model. Understand how the change in the integral step has an impact on the bifurcation and chaos control of the 3D discrete Hindmarsh–Rose model.

2. Research Background

In the field of academic specialization, information technology is defined as the visual operation of tools capable of retrieving, transferring, processing, storing, and applying information. From another point of view, information technology includes all technologies, methods, and systems related to the production, processing, storage, transmission, communication, and application of information, as well as related equipment and tools. In terms of nature, information technology can be divided into hard and soft [3]. Hard information technology mainly refers to the labor technology, labor tools, and the knowledge level of workers related to information, while soft information technology mainly refers to the management methods, management systems, and strategies to deal with problems related to information. The nature division of information technology is shown in Figure 1.

The information technology industry has developed rapidly. The statistics of the information technology industry in recent years are shown in Figure 2.

It can be observed from Figure 2 that the market value of the information technology industry developed from 456.5 billion yuan in 2015 to 718.1 billion yuan in 2021, with an increase of 261.6 billion yuan.

Per capita generated business income of China's software and information technology service industry from 2014 to 2021 is shown in Figure 3.

As can be observed from Figure 3, the per capita generated business income of China's software and information technology service industry was 1.158 million Yuan in 2021, an increase of 8.6% compared with 2014.

The growth rate of the electronic information technology industry in the past six years is shown in Figure 4.

It can be seen from Figure 4 that the growth rate of the electronic information technology industry is all positive. Although the growth rate has declined, it still shows a trend of continuous growth, and there is still a certain space for development in the future.

The realization carrier of the information technology industry is computer. The equipment sales of microcomputers in the last year are shown in Figure 5.

As can be seen from Figure 5, the sales of microcomputer equipment in China have shown rapid growth in the recent year, which also indicates that the development of the information technology industry is promising and there is a huge market potential for its development.

Based on the role generated by information technology in terms of human activities, its role can be summarized into two major aspects: mechanization, and

information extraction and processing. Mechanization can be seen as the increase in the level of mechanization brought about by the recent changes in the level of production, while information extraction and processing has brought about changes in human society in terms of communication.

Differential equations are an important equation in modern mathematics that provide researchers with guidance in solving practical problems in various fields. There are two main types of differential equations: partial differential equations and ordinary differential equations. Partial differential equations have made a major breakthrough and have very broad application in the probability theory, and ordinary differential equations have a comparative advantage in higher mathematics for algebraic problems [4]. Dynamical systems, as a special discipline to study the order of evolution of a certain system with time, can be introduced to the application of differential equations and can be studied as an important subhead in the field of modern dynamics. Mapping iterations and discrete motions with differential equations as the core are an integral part of modern dynamics research. Differential equation dynamical systems contain rich information of application and broad research prospects in the fields and disciplines of geography, mathematics, astronomy, and education. Therefore, the study of differential equation dynamical systems has not only a strong theoretical value but also a strong practical significance [5].

In recent years, in the theoretical study of differential equation dynamical systems, researchers have exhausted their efforts and created many important research results in this field. For nonlinear differential equations, the German mathematician Black and the American mathematician Martos derived a model for the amplitude equation of nonlinear differential equations based on the characteristics of the solutions of quadratic nonlinear differential equations and in conjunction with Veda's theorem. Subsequently, they used the integral step principle and McLaughlin's formula to obtain a model for the amplitude equation of the cubic nonlinear differential equation, and applied the model to the Euler equation through the sensing function of information technology to study the bifurcation and chaos control effects in the model [6].

3. Materials and Methods

3.1. Differential Equation Dynamical System

3.1.1. Concept of the Differential Equation Dynamical System. The differential equation dynamical system has attracted the attention of scholars both at home and abroad and is the approximate solution of the differential equation. The parameter deviation effect caused by the linear differential constant term given by the unknown parameters affects the accuracy of the differential equation dynamical system to the model construction, leading to the approximation of the divergence and convergence effect of the dynamical system [7]. In this article, two types of linear differential equations based on dynamical systems under the convergence effect of

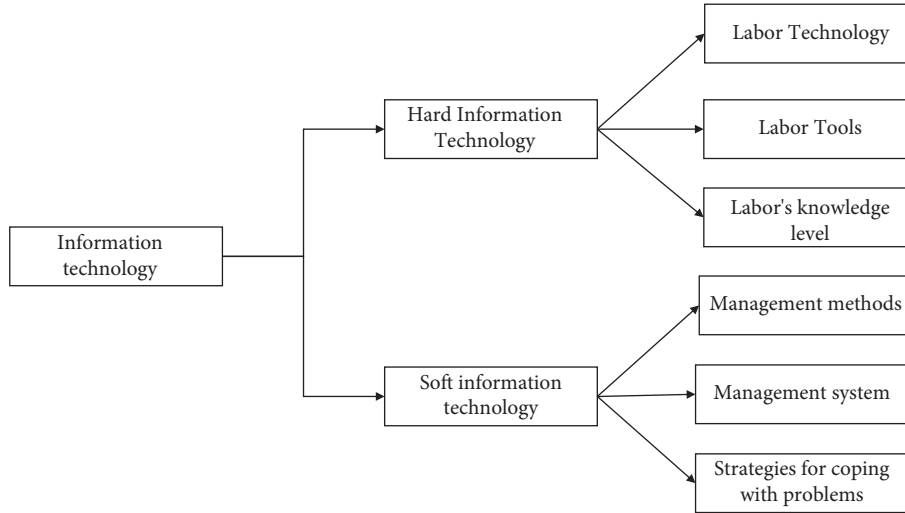


FIGURE 1: The nature of information technology.

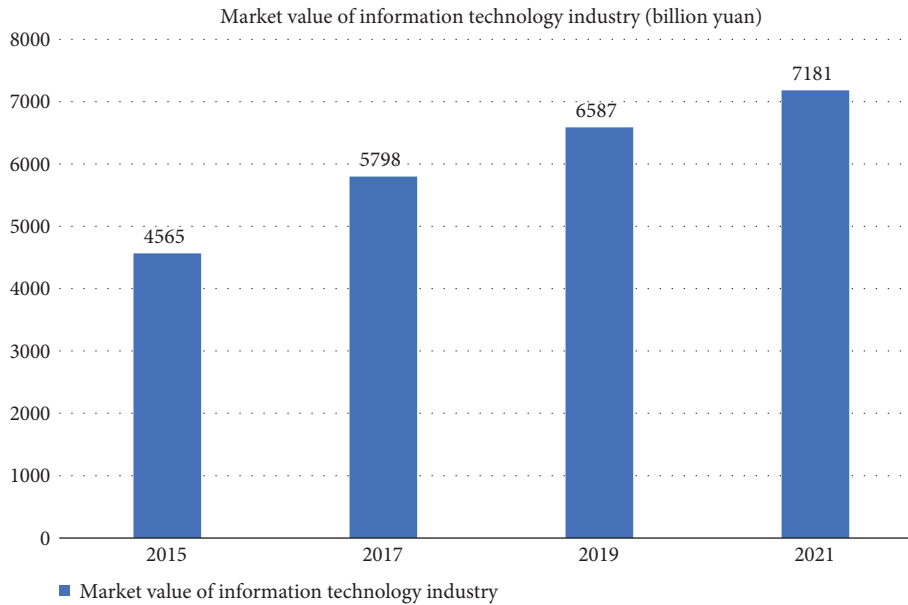


FIGURE 2: Market capitalization of the information technology industry.

equations are derived on the basis of Laplace’s theorem. The first class is the nonlinear differential equations with the parameter terms reorganized by the convergence effect, as shown in the following equation:

$$du = [\xi u + \varepsilon^2 \zeta u + B(u, u)]dt + \varepsilon^{\delta/3} dW, \quad (1)$$

where the stochastic process $= () : [0,] \times [0,] \rightarrow R, A$ is a self-accompanied nonpositive operator, $2L$ is a small perturbation term, a bilinear operator, and a finite-dimensional Gaussian process. The parameters are sufficiently small positive numbers, that is, $0 < \ll 1$.

Another class is the linear differential equations with parameter terms undergoing divergence effects, as shown in the following equation:

$$du = \left[\frac{1}{\varepsilon^2} (\Delta + I)u + B(u, u) \right] dt + dW, \quad (2)$$

where Δ is the Laplace operator, denoting the constant operator, such that the self-concurrent nonpositive operator A in Assumption 1.3.1: $= 12(\Delta+)$. The same, positive numbers with sufficiently small parameters, are bilinear operators and are degenerate Gaussian processes.

When 12 ’s converge to zero, equations (1) and (2) satisfy the conditions for the operation of an effective dynamical system in the limit. And the de-parameterized ordinary differential equations can also satisfy the conditions for the dynamical system operation. This shows that both linear differential equations and nonlinear differential equations can satisfy the operation of the dynamical system after being

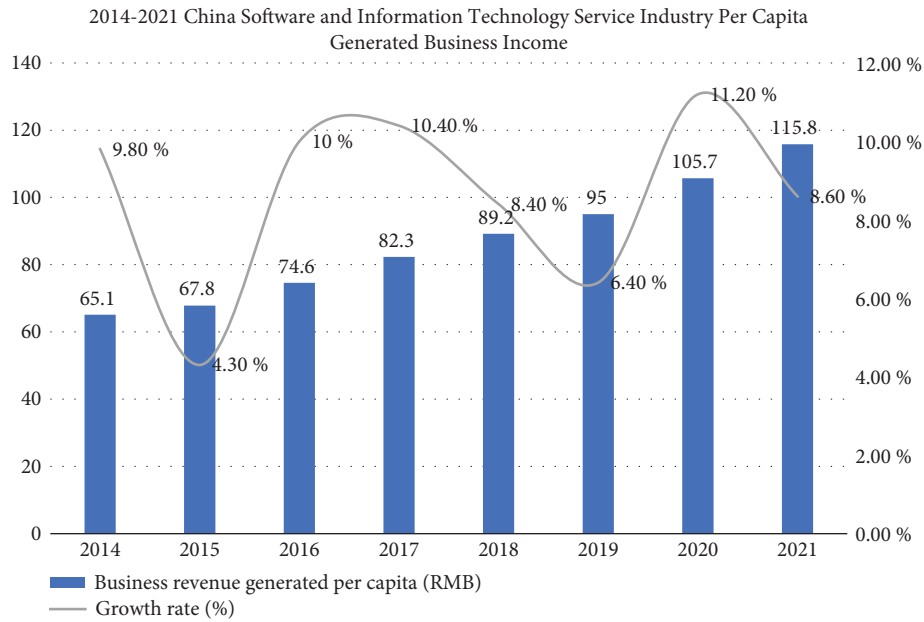


FIGURE 3: Per capita business revenue generated by China’s software and information technology service industry, 2014–2021.

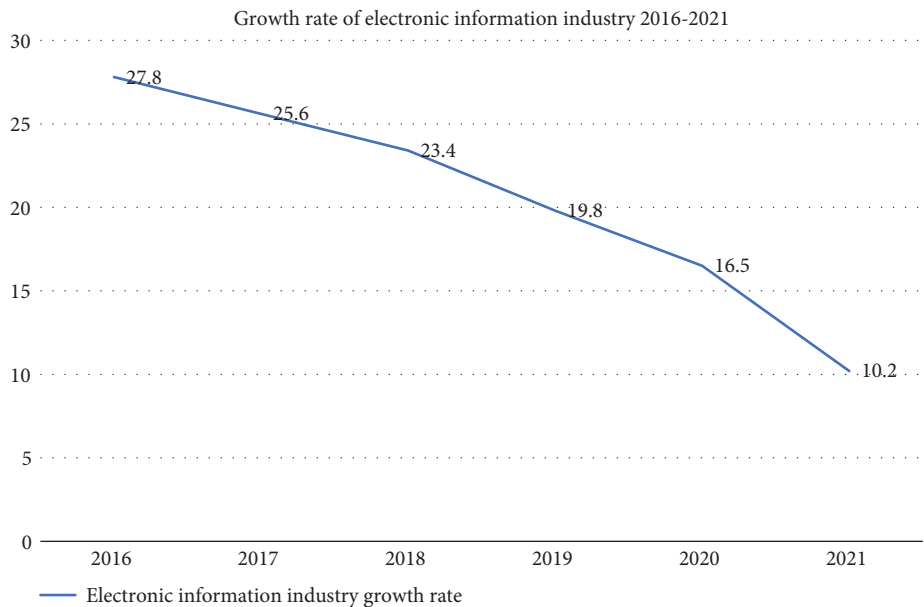


FIGURE 4: Growth rate of the electronic information technology industry.

reorganized by the denoise treatment and given the convergence conditions and approximation forms.

3.1.2. *Denoising of the Differential Equation Dynamical System.* Since the differential equation dynamical system after the denoising process can cause formal deviations after experiencing the effects of additive noise driving, it may have an impact on the final research results [8]. In this article, we decompose the initial stochastic part into a finite space generated by operator A and a non-nuclear space by a proper division of the time variables. The resulting simple

equations describing the nuclear evolution process, that is, the efficient dynamical system, are derived. In addition, the time stop method is usually applied to differential equations in the infinity region. Many examples from physics show that this technique overcomes the difficulty of defining differential equations for infinite regions in the absence of the central manifold theory. Also, this time-stopping method is applicable to finite-area differential equations with arbitrary deviations in the absence of the central form theory [9].

The different degree of denoising also affects the effectiveness of the dynamical system to different degrees. If the

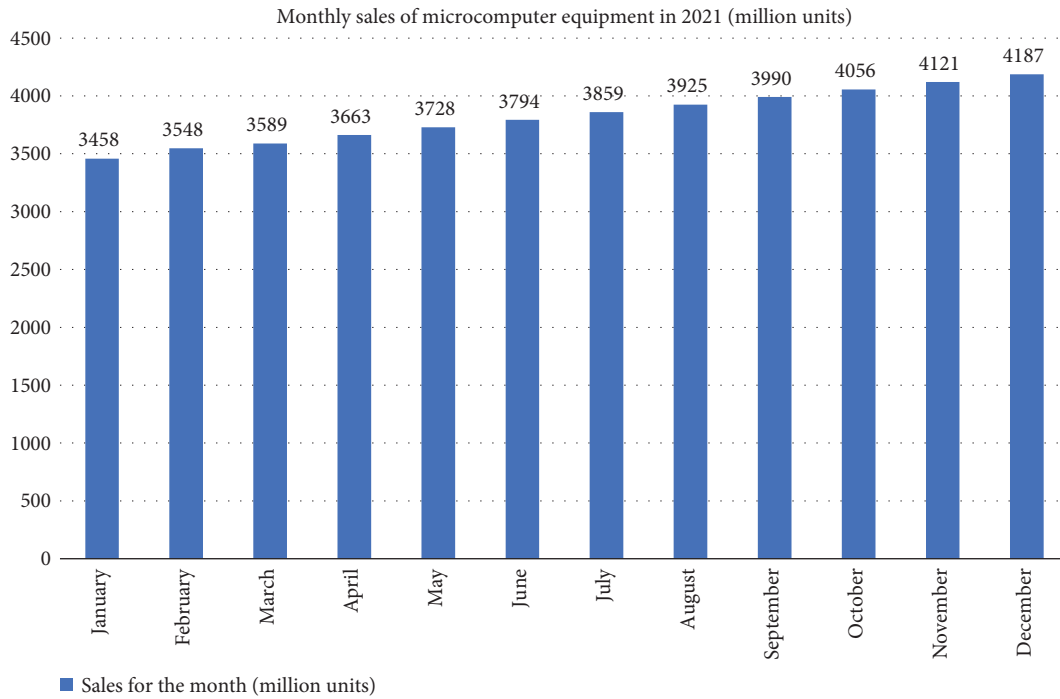


FIGURE 5: Equipment sales of microcomputers in the recent year.

spatial and temporal scales are in the same stratum as the degree of denoising, then the convergence effect of the nonlinear differential equations after the denoising process is received in the model, producing constant term differential equations containing more parametric terms. In addition, the chi-square linear differential equations, after the deconvolution process, cause deviations from the parameter terms in the equations, interfere with the interactions between the linear equations, affect the element replacement in the non-nuclear space, affect the way of reaction diffusion in the differential equation dynamical system, and have a degenerative effect on the dynamical system. For the first type of parameter term after the convergence effect reorganization of the nonlinear differential equations, out of getting the constant terms in the nonkernel space generated in the dynamical system under the play of nonlinear interaction, the effectiveness of the dynamical system can be evaluated by using equation (1) to arrange the elements in the nonkernel space according to the random principle. For another class of linear differential equations with parameter terms undergoing divergence effects, the dynamical system containing only the elements inside the nuclear space is obtained by using the constant terms in the non-nuclear space during the element replacement process [10].

3.2. Selection of the Integration Step Size. The computational speed of the integral depends not only on the length of the integral, but also on the total number of integrals. The calculations involved in each integration step are mainly related to the integration method used and are reflected in the structure and complexity of the derived functions and

the upper differential equations required for each integration step. For most cases, the integration step for differential equations with the highest order, complex structure of the derivative function, and high accuracy requirements should be simulated numerically using the indefinite integration method. For the choice of integration method, it is necessary to make a reasonable choice according to the actual situation; otherwise, it will affect the determination of the integration step and the effect of its role. There are usually three choices of integration methods, which are RW method, Amder evaluation method, and gear correction method [11]. The conditions of applicability of the three methods are shown in Figure 6.

The determination of the integration step size is an important factor that affects the accuracy of the study results. If the step size is too large, it will bring a large truncation error and affect the process and effect of discrete Hindmarsh–Rose model bifurcation and chaos control. If the integration step is too small, it will lead to too many errors caused by the accumulation of the number of calculations, which will eventually increase the total error and affect the normal operation of the discrete Hindmarsh–Rose model bifurcation and chaos control during the calculation. After the integration method is determined, the choice of the integration step is particularly critical. For variables with large variations and fast change rates, it is necessary to use higher strata of the calculation method and to select a step size with a small range of magnitude [12]. For the selection of integration steps relevant to model bifurcation and chaos control, there are selection formulas specifically to determine change of steps, as shown in the following equation:

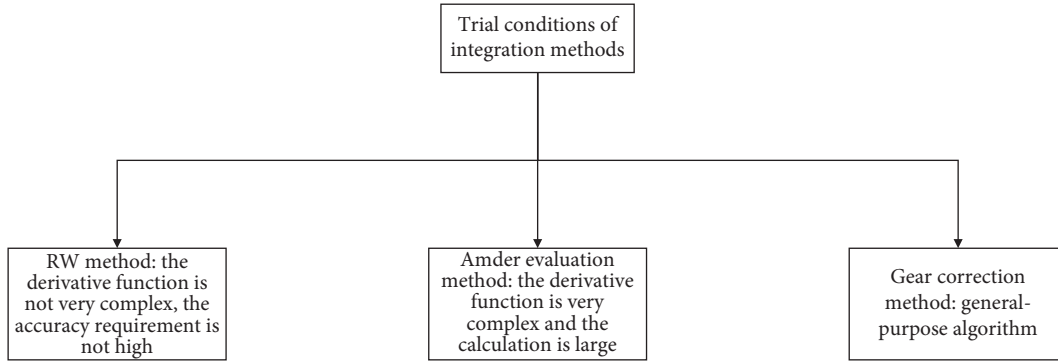


FIGURE 6: Conditions of applicability of the three methods.

$$\left\{ \begin{array}{l} \frac{1}{20}T_{\min} \leq h \leq \frac{1}{5}T_{\min} \\ \frac{1}{20\omega_c} \leq h \leq \frac{1}{5\omega_c} \\ h \leq t_n/40 \end{array} \right. \quad (3)$$

In equation (3), the meaning represented by T_n is the accumulation time of the step integration of the function in the discrete process; ω_c denotes the integration frequency; and t_{\min} denotes the minimum time constant of each part of the integration without long integration.

Usually, the integration step in the selected range is difficult to be accurately estimated, and its performance indicators are in a relatively vague range. The minimum time constant t_{\min} corresponds to the extreme value point, which is limited to the starting form, and the largest role in the whole selection process is played by the extreme value point of the real axis. The calculation of the integration step in the invariant state is chosen according to the criteria of the starting phase, which reduces the occurrence of errors and time wastage caused by the use of too small integration steps in the later phases [13]. In general, there are three strategies for varying the step size: the first one is to vary the step size in segments, that is, by dividing the whole integration process into several segments and choosing a different step size for each segment. The second one is to make a prediction and appropriate adjustment of the next integration step with reference to the sum of errors resulting from the accumulation of each integration step. The third one is to reduce the error accumulation caused by too many integration steps and to select the largest step size without affecting the accuracy of the result of each integration step. By selecting the appropriate step size, the whole integration process is shown in Figure 7.

The above method of automatic step size adjustment has both disadvantages and advantages. The disadvantage is that it leads to an increase in local computation, which not only consumes a lot of time, but also may lead to an increase in the overall error. The advantage is that it solves the conflict between computational accuracy and computational volume in general and finds the maximum balance between the two,

avoiding that the inappropriate selection of integration step size affects the later application results of discrete Hindmarsh–Rose model bifurcation and chaotic control. In the process of determining the integration not length, there are more problems related to the initial values of the system of ordinary differential equations, and solving their analytical expressions is not feasible in the general method, so it is necessary to use the numerical integration method to find the approximate solutions of the ordinary differential equations. Especially for small parameter differential equations, the choice of step size has been a complex and important issue for solving differential equations with small values of the highest-order derivative term. How the step size can be reasonably chosen is crucial to derive the influence of the integral step size on the process and effect of studying bifurcation and chaos control of the discrete Hindmarsh–Rose model [14].

3.3. Types of Bifurcation. Branching theory is the mathematical study of mass or topological variations in galaxy populations, such as the solutions of integral curves and differential equations for families of vector fields. It is usually used in the mathematical study of dynamical systems. If the value of the system parameters (branching parameters) changes smoothly, the system behavior suddenly changes “qualitatively” or topologically. There are two main types of bifurcations: local bifurcations and global bifurcations [15]. Each of the two main types contains several subtypes, as shown in Figure 8.

The analytical entry point of local bifurcation is related to the spatial variation of the equilibrium point of the discrete model in constructing the dynamical system when the parameters cross the critical values. Local bifurcation occurs when changes are made in the location of the equilibrium points due to changes in the parameters [16]. In the discrete Hindmarsh–Rose model system, the equilibrium point at zero can be called the bifurcation point, where the bifurcation parameters are placed at the bifurcation point, and the topological changes are restricted by the position of the bifurcation point to change the original change trajectory, producing a torsional effect so that the equilibrium point is restricted to the minimum neighborhood of the bifurcation point, a phenomenon

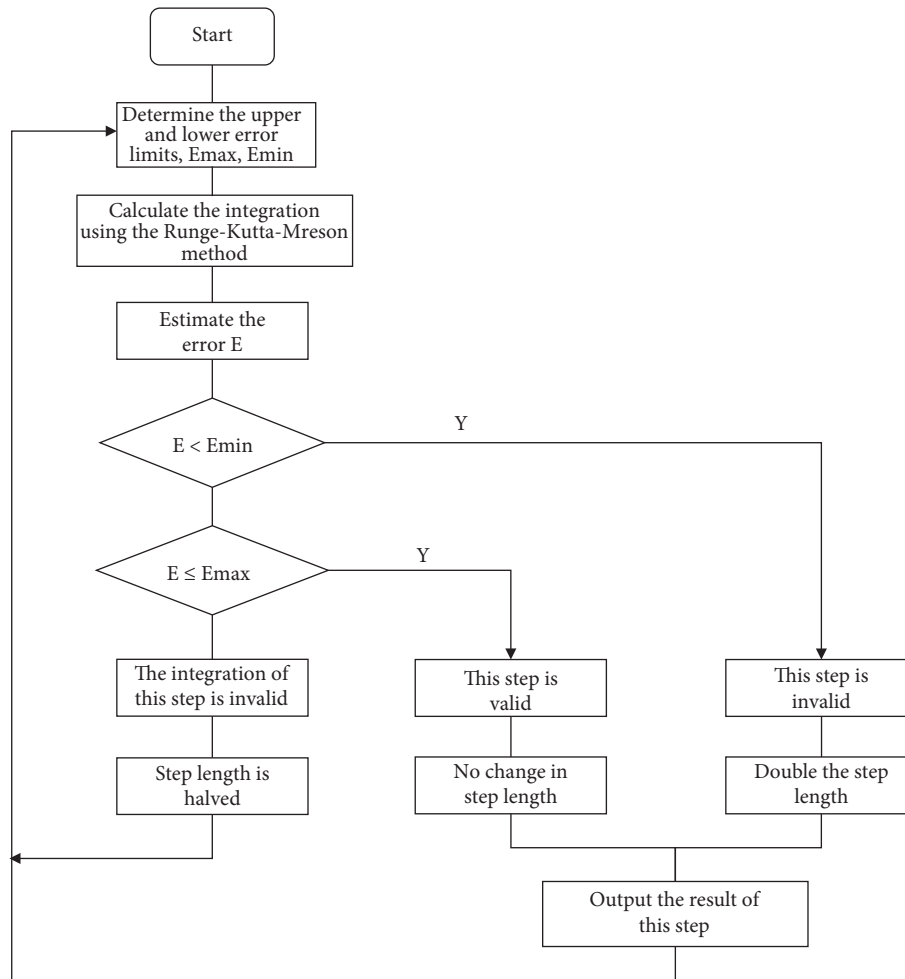


FIGURE 7: Integration process.

known in academia as local bifurcation. There are five types of local bifurcations, namely, folding bifurcation, interactive bifurcation, cluster bifurcation, periodic bifurcation, and Hopf bifurcation.

Folded bifurcation is often found in continuous systems. According to the multidimensional nature of space, not all equilibrium points are in a stable state, and the spatial position of equilibrium points can be replaced at any time due to the mutation and hysteresis effects, resulting in local changes of discrete model bifurcation points. Interactive bifurcation has strong special features in local bifurcation. First of all, it is characterized by the fact that the real part passes through zero values and there exists at least one immobile point where the parameter taking all values takes the equilibrium point without changing. However, if the position of the parameter changes, it should not be understood that the point changes from another fixed point [17]. In other words, there is stability in the collision process with inertial point exchange and unstable mass exchange. A manifold is an unusual type of bifurcation that implies the expansion of the system from one fixed point to several fixed points. Periodic bifurcation is the result of a change in the behavior of the system due to a small

change in the system parameters, producing a cyclic iterative effect. Periodic bifurcation contains several periodic phases that possess a stable temporal pattern, and the magnitude of its periodicity is related to the degree of change of the parameter values. When the parameter values change twice as much as the original degree, the system produces twice as many iterations, then a double periodic phase is generated; that is, the period after the change is twice the original period. The Hopf bifurcation, as a replacement of the stability of the system and the critical point at which the cycle solution changes, is also a special type of local bifurcation. When the system parameters change at the position of the critical value point, the complex conjugate eigenvalues that maintain the normal operation of the system shift in the equilibrium point when passing through the imaginary axis of the complex plane, and will gradually lose its stability and produce limit loops from it.

The occurrence of global bifurcation is restricted to a small area range compared to local bifurcation, which is wider than that of local bifurcation. It usually occurs when large permanent blocks of the system collide or overlap with the equilibrium point of the system. It cannot be analyzed exclusively on the basis of the stability

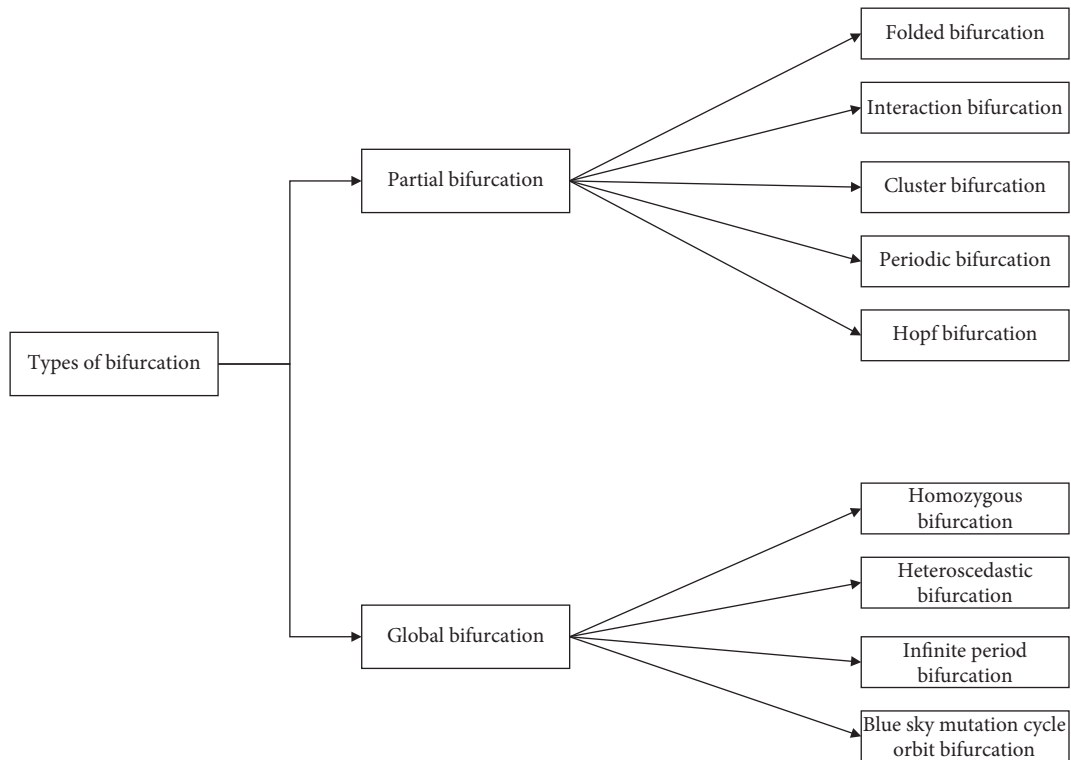


FIGURE 8: Types of bifurcation.

of the equilibrium point (stationary point). Global branches are called global branches because they occur in larger regions than microscopic areas like the partial branches of the authority. There are several types of global offices.

(1) Nighttime separation is a global phenomenon that occurs frequently in collisions of circular trajectories with saddle surfaces. A double rendezvous is produced when a periodic orbit collides with a saddle. For small values, there are saddle points and limit rings. As the bifurcation parameter increases, the boundary reaches the saddle point and produces an infinite orbit. (2) Crossing branches are global branches where the boundary ring collides with two or more saddles. The subclinical branches are divided into resonance branches and side branches. These two branches lead to changes in the stability of the cycle. The stability of the ring changes if the eigenvalues of the equilibrium points in the ring satisfy the requirements of the algebra. This is usually accompanied by the appearance or disappearance of circular paths. If the alignment point of the horizontal eigenvalues passes the zero value, a horizontal transmission cycle is generated. This can also lead to changes in subclinical resistance. (3) Branches with stable nodes and unstable saddles on the boundary are called infinite cycle branches. Infinite cycle bifurcation is a global bifurcation that can occur when two immobile points appear on the boundary ring. When the parameter limit approaches the threshold value, the oscillation speed decreases and the cycle approaches infinity, and the cycle infinity appears at that threshold value. When the threshold is exceeded, two

consecutive fixed points appear in the limit loop, generating an oscillation error and forming two saddle points. In other words, it describes the possible behavior of the differential equation stabilizer by changing the equation. The duration and length of the trace is usually infinite, but it remains confined to a part of the phase space and remains stable until the bifurcation. In other words, the trace disappears into the blue sky [18].

Although the chaos theory is deeply connected to the knowledge of physics, it is actually classified as a branch of mathematics. As an interdisciplinary theory, the chaos theory represents the existence of dynamical system settings with highly connected parameters to the initial conditions in a multilatitude space of apparent randomness [19]. Just as the butterfly flaps its wings to bring a Hurricane in the butterfly effect, in a linear system with a range of parameters, subtle differences in the initial conditions present in the chaos control theory can lead to widely varying results in the operation of the dynamical system, which creates a large disturbance in the future predicted behavior and moreover makes the long-term prediction of the system behavior very difficult or even impossible. Even for very deterministic systems, the butterfly effect can occur. The initial conditions of the system already determine the long-term behavior of the dynamical system, and its behavior is not disturbed by other factors, a phenomenon defined as the chaos effect. The chaos theory has been used to varying degrees in mathematics, chemistry, physics, and biology, and since the first chaos model was proposed in the 1960s, the discussion of the chaos problem has been limited to

theoretical aspects, but not to practice and application. With the expansion of the field and the deepening of the research problems, the study of the chaos theory has increased the application of its research results to human services. Due to the complexity of the chaos theory, the control of chaotic systems is very challenging. However, with the efforts of people, various strategic approaches to control chaotic systems have been discovered [20].

4. Results and Discussion

4.1. Effect of Integral Step Size on Chaotic Control of the Discrete Hindmarsh–Rose Model. In the above material, it can be recognized that the selection of the integration step size affects the accuracy of the results on discrete studies. It is important to avoid both the large truncation error caused by too large a step size, which affects the process and effect of discrete Hindmarsh–Rose model bifurcation and chaos control. It is also necessary to avoid the accumulation of errors caused by too many calculations due to too small integration steps, which eventually increases the total error and affects the normal operation of discrete Hindmarsh–Rose model bifurcation and chaos control.

For the methods of chaos control, academics are mainly divided into two major types: the feedback control method and the minimum energy control method.

American scholars Ott, Grebogi, and Yorke proposed a feedback control method to control chaos with parameter perturbation, that is, using the characteristics of parameter perturbation to make the position of immobile points move relatively to correct the unstable operation of the system state; Hunt introduced a new form of the feedback control method based on the research results of the above three scholars, and this method has extremely superiority. On the premise of not affecting the operation of the periodic orbit, the gain can be adjusted by a small perturbation, so that the change of the trajectory of the high periodic orbit can be controlled within a reasonable range. Since then, the feedback control method has been used by scientists from all over the world as an important method to study the chaos control problem. The feedback control method has been continuously improved and upgraded, and different types of feedback control methods have been introduced, including linear feedback control method, internal force feedback control method, automatic feedback control method, and dispersive feedback control method.

The minimum energy control method basically assumes the theoretical premise that in a normally operating system, the conditions for the emergence of the most stable state of the system always occur when the system energy is minimal. This method has a wide range of use, and both continuous systems and discrete systems can be more appropriate use. Although it has a wide range of applications, this method also has some limitations. For example, the system energy in chaotic systems is difficult to control within the applicable range, and it is difficult to obtain the energy function. Therefore, this method has long been less applied to the study of discrete model dynamical systems.

The scope of the study of discrete Hindmarsh–Rose models mainly includes bifurcation studies and chaotic control. The vast majority of the models are smooth systems, and the study of nonsmooth systems is still in the development field, and there are no clear indicators of development. The study of Filippov systems is a relatively new area of research in the discrete Hindmarsh–Rose model. In most cases, the convex Filippov method can be used to convert the Filippov system describing the differential equations of the right side breaks into a differential [107]. However, Filippov systems have not been investigated based on neuronal models. In neurons, the energy of the membrane potential fluctuates between depolarization (up) and hyperpolarization (down) due to the external excitation or spontaneous movement of ions in the ion channel. This upward movement is called dynamics. The signal propagates along the axis of the neuron to the end of the axis, where it connects with other neurons at the synapse. Thus, action potentials play an important role in intercellular communication. Action potentials can also be referred to as nerve impulses or peak discharges.

4.2. Effect of Integration Step on Bifurcation of the Discrete Hindmarsh–Rose Model. The formal composition of the discrete Hindmarsh–Rose model can be expressed as

$$\begin{cases} \bar{x}(t) = y(t) - ax(t)^3 + bx(t)^2 + I \\ \bar{y}(t) = c - dx(t)^2 - y(t) \end{cases} \quad (4)$$

In the model composition, the slow variable is a quantity that plays a relatively small role and is largely negligible. In the above Hindmarsh–Rose model, the parameters represent a fixed value where $a = 1$, $b = 2$, $c = 3$, and $d = 3$. In this model, the switching control parameters can be set to b and I . Before $x(t)$ reaches the critical value MT, b and I have the maximum values b_{max} and I_{max} , respectively, and when XT reaches the critical value MT or is in the outer domain of the critical value, b and I have the minimum values b_{min} and I_{min} , respectively, which decreases the mode potential energy $x(t)$. For the discrete Hindmarsh–Rose model, previous studies have focused on the theoretical and numerical aspects of bifurcation and chaos control, including the critical value control of the discrete model. In practice, the discrete Hindmarsh–Rose model, excluding its own convergence effect, is rarely used as an important function in operation. Among the models, the impulse action can be topologically obstructive due to the discontinuity of the process and the difficulty of estimating the parameters. During the determination of the auxiliary peak discharge structure model, the minimum current of the membrane potential energy is usually set at 25 mA, and the constant c represents the bifurcation value of the membrane potential energy. By the above setting, the decomposition loop of the system, which is discontinuous reset bifurcation, is transformed into continuous periodic bifurcation. Combined with the experience of the above work, the new discrete Hindmarsh–Rose model subjected to the improvement yields the following equation, as shown in the following equation:

$$\begin{cases} \frac{dx(t)}{dt} = y(t) - ax(t)^3 + bx(t)^2 + I \\ \frac{dy(t)}{dt} = c - dx(t)^2 - y(t) \end{cases} \left. \vphantom{\begin{cases} \frac{dx(t)}{dt} = y(t) - ax(t)^3 + bx(t)^2 + I \\ \frac{dy(t)}{dt} = c - dx(t)^2 - y(t) \end{cases}} \right\} x(t) < MT \\ \\ \left. \begin{cases} x(t^+) = \left(1 - \frac{\zeta x(t)}{x(t) + q}\right) \\ y(t^+) = y(t) \end{cases} \right\} x(t) = MT \quad (5)$$

In the new discrete model, I represents the input DC and p takes values in the range $1 < p < 2$ and q denotes the constant term. $0 < px(t)/(x(t) + q) < 1$ means that the membrane potential energy after resetting is not higher than MT . Considering that the model undergoes abrupt change effects in its state near the critical value, the system periodicity of the pulse action is problematic when compared to the conditions for the occurrence of the pulse action, which can be transformed into the mapped immobile point problem with the addition of the above conditions. Without considering the periodic solution, bifurcation and chaotic control are inevitable focal points in dynamical systems that deserve to be noticed. The path of individual behavior bifurcation to chaotic control transformation is referred to as doubly periodic bifurcation in the academic definition division. For example, if the original period is represented by k , then the doubled period is represented by $2k$, and the quadratic being period is based on the doubled period and the period can be represented by $4k$. Thus, from period k to period $2k$ and then to period $4k$, after many times of multiplication, the doubled period bifurcation has occurred in the fluid after the iterative effect, which sets the air flow rate as a variable parameter and derives the doubled period bifurcation in the neuron model. The range of the multiplicative period bifurcation is very wide, and it can appear in both neuron models and discrete Hindmarsh–Rose models with diversified structures, and it is applied to the study of the behavior of dynamical systems as an important type of bifurcation. The emergence of multiplicative bifurcation is inseparable from the nonlinear term, based on the previous theoretical results; however, according to the present study, multiplicative bifurcation caused by nonlinear impulse action has not yet appeared.

Although the impulse function in the discrete Hindmarsh–Rose model is defined by the academic community as a mapping process that is not connected, the impulse theory is used in this study for the accuracy of the results. For the same system, although the parameter values set are the same, the difference in the selection of the integration step can also affect the effect of the model dynamic transformation play. The characteristics of bifurcation control as an important control method can be corrected using different mechanisms of feedback control methods. One of the most frequently occurring methods is the nonlinear dynamic feedback control method. The target of bifurcation emergence is not only related to the conversion rate of the intrinsic

bifurcation and the point of time parameter, but also related to the change of the parameters of the nonlinear differential equations that emerge from the bifurcation process. The effect of the integration step on the bifurcation of the discrete Hindmarsh–Rose model implies that when the bifurcation process is in an unstable state, the bifurcation stability can be controlled by properly controlling the integration step to generate a limit loop during the bifurcation process to delay the onset of the intrinsic bifurcation and to change the amplitude and interparameter range of the bifurcation point. Compared with the bifurcation control, the inverse control of bifurcation uses appropriate limit-loop amplitude regulation without changing the parameters, and a class of bifurcation with feedback control occurs at a suitable reservation position to realize the integral step for discrete Hindmarsh–Rose model bifurcation and chaos control.

Based on the purpose of the inverse control system to achieve the local balance of bifurcation through the change of parameters on the normal bifurcation of the system output, this article introduces a local bifurcation method in which a pair of real values in the form of complex conjugate complexes is passed through the imaginary axis without changing the function of the dynamical system, and the operation process of the dynamical system still has continuity and stability, and the limit ring in the form of small amplitude is still generated near the immobile point bifurcation type. This type of bifurcation is a common type of bifurcation, and it is not difficult to see it in systems such as chemistry, physics, ergonomics, engineering cost, Internet of Things, and computer networks. The discrete Hindmarsh–Rose model after being affected by a change in the integral step size is shown in the following equation:

$$\begin{cases} \bar{x}(t) = y(t) - ax(t)^3 + bx(t)^2 - \int z(t) + I \\ \bar{y}(t) = c - dx(t)^2 - y(t) \\ \bar{z}(t) = r(s(x(t) - x_r) - z(t)) \end{cases}, \quad (6)$$

where $x(t)$ is the membrane potential energy; $y(t)$ and $z(t)$ are the recovery variables; a, b, c, d, f, r, s , and I are the system parameters; and x_r is the rest potential energy value of the system. In the present case, the explicit criterion for bifurcation and chaos control of the Hindmarsh–Rose model has not been reasonably formulated. The bifurcation and chaos control of the model can be regarded as a way to change the control of limit loops or nonlinear oscillations, and the new bifurcation solution that appears here is the optimal solution obtained after the integration step is regulated, which can be used as a new type of bifurcation solution to balance the parameter composition inside the discrete model system. This also demonstrates that the step size of the integral has a large impact on the bifurcation and chaotic control of the discrete Hindmarsh–Rose model, and provides a reference for the study of chaotic control behavior.

5. Conclusion

The subject of this article is the effect of the integral step size on the bifurcation and chaos control of the discrete

Hindmarsh–Rose model under the information technology-based differential equation dynamical system. In the introductory part of the paper, a brief introduction to information technology and differential equation dynamical systems is given, followed by the introduction of the concept and meaning of the discrete Hindmarsh–Rose model. In the research background, a detailed introduction to the recent developments of information technology and differential equation dynamical systems is further given to set a good background premise for the research content of this article. The article will analyze how the integral step size affects the discrete Hindmarsh–Rose model bifurcation and chaotic control and its effect based on the differential equation dynamical system of information technology. The advantages of information technology in information management and information processing are introduced into the application of differential equation dynamical systems, which can ensure the stability of differential equation dynamical system models. The determination of the integration step size is an important factor affecting the accuracy of the research results. Too large or too small a step size can affect the process and results of discrete model bifurcation and chaos control; therefore, in this article, we understand how the change in the integration step size affects the three-dimensional discrete Hindmarsh–Rose model bifurcation and chaos control through the selection of a suitable integration step size.

In the Materials and Methods section, the differential equation dynamical system is denoised to obtain an optimized differential equation dynamical system that overcomes the shortcomings of the original differential equation dynamical system. And an overview of the chaos control theory is given. Finally, in the Results and Discussion section, the effect of the integration step on the chaotic control of the discrete Hindmarsh–Rose model and its effect on the bifurcation of the discrete Hindmarsh–Rose model are discussed, and it is hoped that the theoretical and practical experiences obtained can provide subsequent workers with the understanding of the bifurcation and chaotic control of the discrete Hindmarsh–Rose model. It is hoped that the theoretical and practical experience gained will help subsequent workers in their understanding of discrete Hindmarsh–Rose model bifurcation and chaotic control.

In view of the limitation of research time and personal ability, there is still some incompleteness in this article. There are still many questions about the effect of the integration step on the bifurcation and chaos control of the discrete Hindmarsh–Rose model that need to be further explored and discovered.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflicts of interest.

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