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Research Article

Information Characteristics, Processes, and Mechanisms of Self-Organization Evolution

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Self-organization is a general mechanism for the creation of new structural pattern of systems. A pattern, in essence, is a relationship, an architecture, a way of organizing, and a structure of order, which can only be explained by information activities. The characteristics of self-organization behavior, such as openness, nonlinearity, inner randomness, inner feedback, information network, and holographic construction, provide corresponding conditions and basis for the self-organizing evolution of the system from the aspects of environmental information function, maintenance and construction of the overall information framework of the system, and exploration of new information mode of the system. Based on the general process and mechanism of self-organization system evolution, its corresponding basic stages have the significance and value of information activities. Generally speaking, the process of system elements differentiating from the original system is the decoupling of information association between relevant elements and original systems. The convergence process of forming system elements is the initial exploration of forming a new information model; the nucleation process of some initial stabilization modes is the creation of information codons; the development of the system according to a particular pattern is ergodic construction of information feedback chain indicated by information codon; the diffusion of system self-replication is the expansion of the quantity of the information model; the variation in system self-replication is the innovation process of introducing new information pattern; environment-based selection and evolution correspond to the complex development of information pattern; and the alternation of old and new structures in system evolution corresponds to the formation process of the whole information network framework of the new system. In order to explain the self-organization's characteristics, processes, and mechanisms of system evolution at a more comprehensive level, the complexity research program must pay enough attention to and give due status to the information factors and information science creed. Moreover, the information science research creed may also provide some basic theoretical paradigms with core theoretical significance for complex system research.

1. Introduction

With the rise of the science group of complex information system since the middle of the 20th century, especially the emergence and development of dissipative structure theory, synergetics, catastrophe theory, hypercycle theory, fractal theory, chaos theory, holographic theory, generalized evolutionary theory, and special complex system theory since the late 1960s, the theory of self-organization mechanism for the formation and development of orderly patterns of open system evolution has been revealed clearly. Moreover, this evolutionary theory of self-organization has penetrated into all fields of natural, social, and thinking development and has been used to explain a wide range of evolutionary phenomena. For example, Dong and Fisher Stuart argue that "The concept of self-organization has become increasingly important for understanding ecosystem spatial heterogeneity and its consequences. It is well accepted that ecosystems can self-organize, and that resulting spatial structures carry functional con- sequences" [1] when they discuss the

problem of self-organization of ecological space; Weise used self-organizing process to explain the law of economic development in evolution and self-organization: "If we define economic as a socio-economic, irreversible, time-consuming process, in which an economy reproduces itself and varies its elements, we see that the principle of self-organization is responsible for part of evolution. Self-organization processes thus constitute, destroy and re-constitute regularities in economic evolution" [2]. And Di Biase and Rocha used information organization theory to solve the problem of consciousness: "It follows that a holoinformational and self-organizing theory, capable of integrating consciousness to the non-local quantuminformational tessitura of the universe, can solve the question of consciousness nature" [3]. In addition, the latest papers show that some scholars have studied the process and characteristics of self-organizing behavior in very specific problems such as robot [4] and cellular objective in *Escherichia coli* [5].

However, the paper focuses on the general information characteristics, information processes, and information mechanisms of system self-organization evolution in a general sense, rather than a detailed description and analysis of the self-organizing behavior of a particular system or domain. Therefore, the self-organized information characteristics, information processes, and information mechanisms described in this paper are applicable to almost all evolutionary mechanisms of general systems. Therefore, it is hoped that those who study the self-organizing process of a particular system will be more or less benefit from or inspired by this article.

2. Organization, Self-Organization, and Hetero-Organization

2.1. Organization. The concept of organization is the superordinate concept of the concept of self-organization.

In general, the concept of organization can be defined in both static and dynamic senses.

The concept of static organization refers to the ordered pattern of a system structure, which is equivalent to the order, pattern, architecture, structure, and so on.

The concept of dynamic organization refers to the process, approach, mechanism, and mode of the formation of an orderly structure of a system, which corresponds to the ordering, structuring, ordering, organizing, and so on.

In the dynamic sense, the concept of organization can be divided into self-organization and hetero-organization, which are defined according to the differences of the specific mechanism and mode of the generation of ordered structure.

2.2. Hetero-Organization. It can be defined as the process of introducing pattern information directly from outside the system and constructing system patterns according to this pattern. The key to understanding hetero-organization concept is that patterns are imported from the outside, not generated spontaneously from within the system, for example, the process in which workers work according to the external instructions issued by the foreman, leading to the joint action of production; the crystals grow in accordance with the mode of implanted embryos; the factory produces replicative products in accordance with the introduced product model; and corresponding reforms are carried out according to the reform experience of existing precedents.

2.3. Self-Organization. Self-organization can be defined as a process in which the system spontaneously forms an internal orderly structure in an open context [6]. The key to understanding the concept of self-organization is that patterns are generated internally and not imported from outside the system. In fact, the generation of any new ordered structure pattern is realized through self-organization. Self-organization is the general mechanism for the creation of new models. For example, the production process of collective operation of workers through active cooperation and tacit action; the process of spontaneous generation of laser wave train in laser; the process by which living bodies construct their own flesh and blood bodies and organs by absorbing external materials and energy and creative reform process without precedent.

2.4. Unity of Self-Organization and Hetero-Organization. Both hetero-organization and self-organization are the process of the generation of the orderly structure of the system, and both of them depend on the openness of the system to the outside world. The difference between them lies only in the nature of external input factors. In the actual process of system evolution, there is no absolute boundary between hetero-organization and self-organization, and according to self-organization theory, two kinds of processes can be described from a unified point of view. In fact, the process of hetero-organization can be regarded as the replication or diffusion of new patterns created in the process of self-organization; thus, the creation of a new ordered structure of matter or information is a self-organization process, and the hetero-organization process is correspondingly regarded as a necessary step for the diffusion or amplification of the self-organization process. Further, hetero-organization corresponds to the quantitative growth of the established pattern, and self-organization corresponds to the qualitative evolution of the creation of the new pattern.

2.5. Types of Self-Organization. On the basis of the types of orderly structures spontaneously formed by the system, the self-organization phenomenon can be divided into two types: spatial self-organization and temporal self-organization (or spatiotemporal self-organization).

The phenomenon of spatial self-organization refers to the orderly spatial structure formed spontaneously during the evolution of the system by means of self-organization. Typical physical experiments include hexagonal nested honeycomb structure and large rolling wave structure formed by Bernard convection, ordered light wave train produced by laser, etc. There is a very common phenomenon of spatial self-organization in nature and society such as the

"cloud street" in the sky, the stratified color of geology, the cracking of dry land, the whirlpool in the river, the mode of organism, the hierarchical structure of social groups, the mode of human flow when entering or leaving a large conference or performance, and the distribution of natural villages. Temporal self-organization (or spatiotemporal self-organization) refers to the phenomenon that the ordered spatial structure formed spontaneously during the evolution of the system changes periodically with time through self-organization. Typical experiments are chemical clocks, chemical waves, and chemical helices. There is also a very common phenomenon of temporal self-organization (or spatiotemporal self-organization) in nature and society, such as the periodic change of sunspot; the periodic oscillation of the number of predators and prey in the ecosystem with time; the alternating cycle of the Earth's four seasons climate; the phenomenon of human biological clock; the periodic fluctuation of economic prosperity and recession; the alternating movement of stock market appreciation and decline; the beating of animal heart; the fluctuation of psychological activity; and the relaxation of mental state.

2.6. Essence of Self-Organization. In the sense that self-organization is a qualitative evolutionary process of creation of new patterns (spatial, temporal, or functional), it is clearly impossible to explain self-organization in terms of pure matter (mass) or energy activities. System models are not simply defined by factors such as mass or energy. A pattern is essentially a relationship, an architecture, a way of organization, a structure of order, and such things as a relationship, an architecture, a way of organization, and a structure of order can only be explained by information activities. Here, activities such as quality or energy are only the carrier form of information activities. The holistic system science program emphasizes that the system is the relationship between elements or that the system is the relevant provisions of the network of relationships. From the point of view, the specific mechanism of the existence and evolution of the system cannot be clearly explained only by the activities of mass or energy.

3. Information Characteristics of Self-Organization Activities

The literature on self-organization theory describes the basic characteristics of self-organization system in many aspects, including dynamics, openness, nonlinearity, randomness, and complexity. However, due to the lack of information dimension investigation in relevant descriptions, it is difficult to carry out in-depth research. Although many researchers have noticed the key role of the information factors in the research of self-organizing systems, most of their studies are still specific descriptions of individual self-organizing activities, which are lacking an abstract explanation of the general characteristics and mechanisms of self-organizing systems: Polani et al. pointed out clearly in the study of guided self-organization theory (GSO) that: "One of these themes is the role of information (understood as Shannon information, i.e., "reduction in uncertainty") in guiding a self-organizing process. In particular, a lot of progress has been achieved in studying various aspects of information structure and information processing during self-organization of behavior (molecular, neural, cognitive, social, etc.)." However, their articles still focus on self-organizing activities in specific areas such as the nervous system, biological system, and social system [7].

In addition, it is also worth mentioning the work of the founder of synergetics, Haken, who is still very diligent in thinking and writing, despite his advanced age. In recent years, he has published several articles: "Self-organisation and information in biosystems: a case study [8]," " Water Freeman and Some Thoughts on Brain Dynamics [9], " "Information adaptation in urban design [10]," "Information and self-organization [11]," "Information and self-organization: a unifying approach and applications [12], " and in these articles, he not only makes a case study of the relationship between specific self-organizing systems such as biological systems, brain dynamic systems, urban design systems and information but also conducted an in-depth discussion on the relationship between information and self-organization. However, he explained the self-organization process mainly based on the level of information science, such as Shannon's grammatical information theory and other scholars' relevant semantic information and information science of pragmatic information. This kind of scientific investigation inevitably has its limitations. The philosophy of information has reexamined and explained the basic characteristics of self-organization process from the perspective of information activities so that we can grasp the essence of self-organization phenomenon more deeply.

The philosophy of information created by Professor Wu establishes the ontological status of information on the ontological level of philosophy on the basis of combining the relevant modern scientific achievements of complex information system theory with the creative interpretation of the problem of "existence" of philosophy. And his definition of information is "Information is a philosophical category indicating indirect being. It is the self- manifestation of the existing mode and status of matter (direct being)" [13]. One of the core values of this definition is to establish the dual existence of matter information of the whole world and all things in the world. It is in the sense of dual existence of material information that we can say that system evolution is not only a material behavior but also an information behavior, and material system can be interpreted from the perspective of information system. Both the characteristics and evolution of self-organizing systems have "information characteristics." This is the basic connotation of "information characteristics" of the evolution of self-organizing systems.

3.1. Preservation of Dynamics and Information Model and the Construction of Complex Reorganization. The related self-organization theory distinguishes two kinds of ordered structures: one is static, such as the lattice pattern (microscopic particles are arranged in a statically ordered space),

which is called "dead structure" by Haken; the other kind is dynamic, which is characterized by that the macroscopic ordered structure of the system is maintained by the movement or continuous replacement of the microscopic particles that make up the system. Self-organization is a dynamic and orderly structure. The so-called self-organization phenomenon is the orderly structure of the whole system which is maintained or developed in the continuous transformation of the fabric elements. For example, the vortex in the river, the Benard flow, and the pattern of human body are constantly changing and replacing the microscopic components, while the macroscopic overall pattern is relatively stable and unchanged.

Dynamic order is concerned with the maintenance or growth of the orderly global information structure (pattern). As for the flow or substitution of micro mass energy, it is only the form of carrier movement that ensures the maintenance or growth of the orderly global information structure (pattern). Here, the order pattern emphasized by self-organization can only be established in the sense of stable maintenance or complex evolution of information activity pattern. Order is a framework for encoding information. The maintenance of ordered structure is relative to the stability of specific information coding architecture. In dynamic order, the aspect that marks the essential invariance of a system is neither the quality nor the energy of the system. The quality and energy of the system are always flowing and changing, and only the architecture of the corresponding order of specific information coding is the sign of the nature of the system, because only this architecture is stable. A complex evolution of an ordered structure is a complex reorganization or construction relative to a specific information coding framework (more orderly new structure generated), the degree of system self-organization growth and the increase of the complexity, that is, transitional evolution from an ordered state to a more ordered state are based on the complex reorganization or construction of a specific information coding framework. As for the activities of quality or energy exchanged within the system or with its environment, they are organized through the complex reorganization or construction of this particular information coding framework, or the former is incorporated into the orderly mode construction process of the latter and adopts a unified and coordinated mode of operation subordinated to the latter (Haken language). Only by understanding the essence of self-organization from such a level can we accurately grasp the significance of Haken's order parameter and Eigen's hypercyclic framework theory.

3.2. Necessity of Appropriate Openness and the Role of Environmental Information in Self-Organization Evolution. The orderly structure of self-organization can only be formed and maintained by absorbing material (mass), energy, and information from the outside world. For example, Bernard convection is generated in the process of absorbing heat from the outside world. Chemical oscillations can only be maintained with the constant addition of chemical reactants; once the addition process stops, the oscillations will gradually decline and eventually lead to an equilibrium state of uniform mixing. On the contrary, static ordered structures like crystals are often formed in the process of releasing energy to the environment and can maintain their own stability under relatively isolated conditions. According to the relevant principles of dissipative structure theory, the appropriate degree of openness is a necessary condition for the external environment to impose nonequilibrium constraints on the system. Constraint refers to the continuous effect of the environment on the system, which is different from the instantaneous external disturbance, and the constraint will inevitably cause the response or response of the system, which is adaptation. Only in the state of adapting to constraints can the system maintain or form a stable macrostructure. When the external constraints change and the original state of the system no longer adapts, the system begins to seek a new state to adapt to the changed constraints. The system adapted to zero constraint is a macro-disordered equilibrium state, and only the system adapted to the appropriate strong constraint can form a stable macro-ordered structure. The constraints imposed by the external environment on the system and its impact on the structural changes of the system are not only at the material-energy level but also at the information level. "At the formation of a stationary dissipative structure, the production of information in the process of structuring attains a maximum, so that structuring is the process of producing and materializing information" [14].

Here, on the one hand, appropriate openness refers to the nature of the role introduced from the environment (the nature of this role must be able to resist the entropy generated spontaneously within the system) and, on the other hand, refers to the degree of openness, that is, the relevant role introduced must be strong enough (its dosage must be equal to or exceed the amount of entropy generated spontaneously within the system). When they are equal, the macro-ordered structure of the system remains unchanged; when the amount exceeds the amount of entropy spontaneously generated in the system, the system will increase its ordered degree. In this regard, the relevant evolutionary theory emphasizes the unity of quality and quantity of the open conditions for evolutionary behavior.

The exchange between open system and environment is not only about mass or energy but also about the nature of mass energy, the structure of order of mass energy, the degree of organization of mass energy, and the nature, way, and mode of their matching, interaction, and influence with the existing structure of order of mass and energy within the system, and the order of organization. Such as the structure of order, the order of organization, and the ways and means of mutual matching, function and influence can only be established in the sense of information activities. According to "the principle of the increase of entropy (the second law of thermodynamics)" of Clausius, under isolated conditions, the system always evolves in the direction of entropy increase of disorder and tissue degradation. The quantity measured by entropy here is not about quality or energy, but about the mode of order formed by mass energy (elements), the structure of relations, the order of organization, and the

degree of unity and coordination of the mode of mass-energy operation.

I. llyaPrigogine extended the second law of thermodynamics to open systems and established the generalized second law of thermodynamics accordingly. According to I. llyaPrigogine, under the open background, the system introduces the "external entropy flow" from the environment, which may lead to the complexity of the entropy change behavior of the system. If the property of the "external entropy flow" is contrary to the property of the "internal entropy change" spontaneously generated by the system, that is, the entropy with a negative sign, and when the absolute quantity of the "external entropy flow" is greater than the absolute quantity of the "internal entropy change," the system will evolve along the orderly entropy decrease direction, which is the occurrence of the self-organization evolution event in the general sense.

In his famous book "What is Life?" published in 1944, Schrodinger not only put forward the idea that life depends on "genetic code" but also put forward the famous conclusion that "life depends on negative entropy for food" [15]. In the book, Schrodinger emphasized that the way in which living organisms avoid decline does not depend on the amount of substances (mass) and energy they absorb from the environment, but on the negative entropy carried by these substances (mass) and energy carriers (factors contrary to the increasing trend of spontaneous entropy in the body), i.e., structure, order, and organization.

Obviously, neither I.llyaPrigogine's "external entropy flow" nor Schrodinger's "life depends on negative entropy for food" can be explained simply by factors like mass and energy, but only in the sense of information activities.

3.3. Nonlinearity and the Overall Information Architecture of the System. In all disordered systems and static ordered systems, the interaction between microscopic particles is "short-range," random, and noncooperative, that is, the interaction only occurs between each particle and its distance is microscopic. In the self-organization system, the interaction between microparticles is "long-range," that is, a large number of microparticles act in concert to form a whole nonlinear stable model, resulting in macroscopic observable results. The same is true for Benard convection and chemical clocks. Systems such as living organisms and societies are considered self-organizing because they are dynamic, open, and nonlinear. For example, organisms are orderly structures formed and maintained by constantly entering and discharging substances (mass), energy, and information, which are commonly referred to as metabolism. Cells and organs in vivo are long-range coherent patterns of biological macromolecules. In human society, families, communities, enterprises, governments, and countries are orderly structures formed by means of long-range communication. They generally do not change with the flow of their members and constantly exchange materials (mass), energy, and information with the environment. In different self-organization systems, although the relative scope of macro and micro is different, the meaning of unity does not change.

In fact, the internal operation mechanism of nonlinear or long-range coherence emphasized by self-organization theory is not only for the internal mass and energy of the system but also for the mutual matching, combination, and unified operation mode of mass and energy, as well as the overall structure, order and pattern formed. Here, nonlinearity and long-range coherence are the ways of coordination and cooperation between the elements emphasized by Hacken. Based on this understanding, we say that the essence of nonlinearity or long-range coherence is not determined by the quality or energy of the system itself, but by the approach, way, order, and mode of organizing the corresponding mass or energy, which is the existence in the framework of the overall information model of a system.

3.4. Internal Randomness and the Evolution of the Overall Information Model of the System. There are two kinds of randomness: external randomness and internal randomness. External randomness refers to the randomness generated by the interference of the external environment, which reflects the influence of the random uncertainty of the external environment on the system motion. Internal randomness refers to the inherent randomness in the system itself, which is generated spontaneously within the system. Chaos theory reveals that as long as the deterministic system has a slightly complex nonlinear, internal randomness will be generated within a certain range of external control parameters. Therefore, the movement mode of the future evolution of the system triggered by internal randomness of the class will be random bifurcation, irregular, aperiodic, and extremely complex. Even if the initial conditions and external control parameters have been determined, the future evolution mode of the system is still inconclusive. The internal randomness caused by nonlinearity leads to the diversity, uncertainty, and complexity of the ordered evolution direction and mode of self-organization systems.

The generation of internal randomness in the system is caused by the independent movement of the elements that make up the system and the random interaction among the elements and between the elements and the whole system based on the independent movement. Therefore, the generation of inner randomness is actually rooted in the complexity of random variation of microelements. The reason why the system evolution is sensitive to the initial value (butterfly effect) according to Chaos theory is rooted in the variable complexity of microfactors because, even if the initial value measured is identical. However, since the elements that constitute the system itself have the variability of "free will" (active elements), the system will also produce the differences in intrinsic conditions (Independent uncertainty) that can cause changes in sensitivity in the evolution of the subsequent, which leads to the future evolution pattern of diversity and complexity.

The complexity of random variability of microelements is determined by the multilevel structure of the system. In fact, the elements are only specified at a specific level of the system. At a more microscopic level, the elements themselves are a system, and the elements also have their own elements, which are also relational networks of a specific

information framework. In this way, the elements have the overall property relative to their internal structure, and the interaction between the internal structures will also cause the corresponding change or disturbance of the integrity of the elements and further affect the way in which it interacts with elements and the way in which elements interact with systems at the upper level. Such influences constitute the autonomous uncertainty of the above factors and the occurrence of random behaviors within the system. In the sense of information activities, the autonomous uncertainty of these elements and the internal randomness of the system are constructive activities in exploring new information frameworks and patterns, especially at the critical point of information pattern replacement of self-organizing evolution of the system, such random exploratory behavior may become a mechanism for selecting future evolution patterns and directions of the system.

3.5. Internal Feedback, Information Network, and Holographic Constructiveness. Feedback is the transmission and return of information, and the key to its meaning is "return." Cybernetics reveals that a complete control process is achieved through feedback of information. Relative to the behavior of a system, feedback can be divided into two types according to the scope of feedback: external feedback and internal feedback. External feedback refers to the fact that the information function of the system to the environment will change the environment, which in turn affects the behavior of the system. Internal feedback refers to the information feedback loop formed by the interaction between the elements within the system and between the elements and the whole system. In fact, any interaction is maintained by an information feedback loop.

The autonomous movement of system elements and the random interaction between elements and between the elements and the whole system will inevitably lead to multilevel, multidirectional, and complex internal feedback loop. It is precisely the holistic information network system formed by the further interlocking activities of many levels and complex internal feedback loops that constitutes the mechanism of the whole nonlinear interaction within the system. It is also in the sense of this particular information network system that the holistic nature of the system is justified to be regarded as a specific relationship network. It is the whole information network system including multilevel and complex internal feedback loop that leads to the whole coexistence and covariance of the internal elements of the system, the microdynamics and uncertainty of the operation mechanism, and the two-way construction and transcendence of two-way new quality of system and elements [16]. It is also the holographic mapping and construction of the whole new quality of the system.

3.6. Complexity and Information Science Creed [17]. Complexity research creed is a more overall and comprehensive scientific research creed. Complexity research creed emphasizes the internal randomness of the system, the autonomy of the elements, and the interdependent and relatively independent characteristics of the system and the elements, the system and the environment, further dialectically unifying reductionism and holism (emergence theory), determinism and nondeterminism, internal randomness and external randomness, internal and external feedback, elements and the overall relationship network, quality-energy factors, and information factors.

In fact, the complexity research creed can give a comprehensive and overall description of the self-organization characteristics and mechanism of system evolution. Combined with the characteristics of the five aspects mentioned above, we can clearly see that complexity is a more essential and basic characteristic of self-organization behavior, which is built on the organic synthesis of many other basic characteristics of self-organization behavior.

Because of its unique position and role in the development of contemporary science and the irreplaceability of its new research perspectives, the complexity research creed must pay enough attention to the information science research creed. Moreover, from the above self-organizing characteristics of the meaning of information activities, we can clearly see that information activities themselves are very complex. Therefore, it is reasonable to say that the research creed of information science may provide some of the most fundamental and core theoretical paradigms for the research of complex systems.

4. Information Processes and Mechanisms of Self-Organization Behavior

Generally speaking, the creation and evolution of a particular system generally need to go through several links, such as differentiation, convergence, nucleation, development, replication, diffusion, mutation, selection, evolution, and destruction. If the internal mechanism of these links is discussed from the scale of information activities, it will be possible to reveal the general mechanism of organizational behavior more deeply.

4.1. Differentiation and the Decoupling of Information Relevance of the Original Systems. This is an evolutionary process in which the components (elements) of a new system are free from the constraints of the original system. The process can be regarded as the information coding framework of the original system, the instability of various internal and external feedback loops, and the decoupling process of deconstructed information correlation under the action of specific environmental information. Moreover, the process can correspond to the self-destruction process of extreme degradation evolution of the original system, as well as the quality-energy spilt or external release of some elements caused by the internal and external interaction of some systems that destabilize the original structure. Differentiation and evolution provide possible preconditions for the self-organizing creation of subsequent new systems.

4.2. Convergence and Exploration of New Information Pattern. It is an evolutionary process in which the differentiated components gather to a certain abundance, compete with

each other or attract each other, and further differentiate or cluster on this basis. The process can be seen as a tentative establishment process of new information coding framework patterns, various possible information coding framework patterns, and corresponding internal and external feedback loops under the influence of specific environmental information.

4.3. Nucleation and Generation of Information Codon. It is an evolutionary process in which one or several information architectures formed in the convergence process are stabilized and play a central role in attracting and providing information templates for the specific construction of the overall order mode of the new system. And the process can be regarded as the initial indicator or the initial information codon creation process to form the overall ordered information coding framework pattern of the new system. On the one hand, the initial process of information codon creation depends on the nature and intensity of relevant constraints provided by the appropriate external environment. On the other hand, it depends on the independent random activities of the relevant parts or components and the random interaction between the relevant parts or components that have been previously aggregated in the system. It is in this kind of exploratory activity that the relatively stable information feedback chain pattern may be formed locally, thus becoming the initial information codon of the whole orderly structure construction of the system. If there is more than one type of information codon initially formed, then competition will take place among multiple initial information codons, and the result may be that only one kind of information codon is preserved and developed, while other kinds of information codon may disappear in the competition or may form synergistic effect among many kinds of information codon, thus establishing a more stable information feedback chain model framework on a macro scale. For example, the hexagonal pattern presented by Bernard convection is supported by three information codons (corresponding to the three edges of each triangle in the six triangles divided by the hexagons). If the system is heated continuously, when a new threshold is reached, the hexagonal pattern of the Bernard flow will be transformed into a large roll structure, at which time there is only one information codon that determines the large roll structure. The few information codons that can indicate the overall behavior of the system are called "slow mode" or "ordered mode" by Harken, the founder of synergetics. The corresponding evolution equation containing only a few slow modes is called the "order parameter equation," while the variables representing the slow modes in the equation are called the "slow variable" or "order parameter" correspondingly.

4.4. Development and Ergodicity Construction of Information Feedback Links Indicated by Information Codons. It is an evolutionary process in which the global stable structural framework is further grown or developed in accordance with the established template of the nucleus as the center of attraction for the new system. The process can be regarded as the process of expanding or expressing the information coding framework of the new system by the information program specified by the initial information codon. On the one hand, the process of constructing the system's overall orderly stable structure mode depends on the stable and continuous existence of appropriate external constraint conditions; on the other hand, it depends on the ergodic establishment of relevant information feedback links among various elements within the system. It is precisely the ergodicity of the corresponding information feedback chain that leads to the adoption of a unified overall coordination or synchronized cooperation among various elements of the system in accordance with the pattern indicated by the "core" which has already formed, which is the overall synergistic effect of "model-following coordination" emphasized by Haken.

4.5. Replication, Diffusion, and Extension of the Quantity of Information Pattern. This is an evolutionary process in which a system manufactures the same system according to its own pattern, and it is a general evolutionary mode in which the phenomena of life are inherited. The process is the information coding framework of the system, through the link of self-replication of information, to maintain and continue its own information pattern and further expand its own information pattern in quantity. It is through self-replication that the initial structure of life, which accidentally arises in the random process, acquires the constant multiplication and diffusion of the quantity of "Once created, it lasts forever" (Eigen). Milenkovic and Vasic said "A gene regulatory network describes a natural iteratively decodable code with the function of both adapting the cell to its surrounding and enabling accurate replication of genetic information" [18].

4.6. Variation and Innovation of Information Pattern. It is a new mode that is not exactly the same as the copied mode due to errors in the replication process, that is, the evolution process of the generation of the new system. The process corresponds to the information activity process in which the original information coding framework is changed and the new information coding framework is created by copying errors. The inducement of variation may come from the accidental stimulus of external randomness provided by the environment or from internal randomness inherent in the system. Due to the existence of internal randomness, variation will be an inevitable phenomenon in biological evolution. According to the results of related research, the mutation rate at the level of life gene has approached a constant for millions of years. It is precisely the inherent randomness within the genetic structure of life that can reasonably explain this phenomenon.

4.7. Selection, Evolution, and Complex Development of Information Pattern. As long as the new model created is not eliminated in the competition with the original model, it

may develop by the choice of the environment or develop independently in parallel with the old model or replace the old model to occupy a dominant position in development or support and coordinate with the old model to form a more stable and large-scale new system. This evolutionary process constitutes what is commonly referred to as orderly and complex evolutionary events. What makes this process go on smoothly is the selection of appropriate environmental information on the corresponding information coding framework. "Survival of the fittest" promotes evolution at the level of information mode selection.

4.8. Alternation of Old and New Architectures and Formation of New System Integral Information Network Architecture. In the process of natural evolution, there may be an evolution process of alternating old and new structures in the same system. If the new structure is more orderly than the old structure, it will be the evolution of the system; otherwise, it will be the degradation of the system. Generally speaking, once the overall structure of the system is established, it tends to maintain stability, which is the "inertia" of the general system. But "inertia" is a conservative tendency that hinders evolution. In order to evolve, the system must first break the "inertia," which means that the original structure must be destabilized. That is why Haken emphasized the important role of instability in the orderly evolution of a system. In order to destabilize the original structure of the system, the system must have some novel mechanism. Specifically, the reasons for the instability of the original structure and the search for a new structural mode of the system are generally from three aspects: first, the change of the original relatively stable external environment; second, the influence of accidental external randomness (external fluctuation); third, accidental effects of randomness (internal fluctuations) within a system. Generally, due to the change of the external environment, the system structure that adapts to the original external environment constraints can no longer adapt to the new external environment constraints, so the original system structure will be unstable. However, the instability of the old structure to the establishment of the new structure depends on the exploration of a new structure, and the power to explore the new structure comes from the accidental external or internal randomness, or the interaction of internal and external randomness. Due to the bifurcation of the path of system construction, the interaction of inner and outer randomness is the key factor to explore and select the new structure. This is the self-organization theory emphasizes that "fluctuation is the power of systematic orderly evolution." Although the new structure is selected by random exploration, whether the new structure can be stable or survive for a long time depends on the adaptability of the new structure to the external environment. Therefore, the stable and open environmental background conditions become the selection factor of whether the new structure can survive stably. The principles of openness, "survival of the fittest," and "elimination of inferior" are all established in the sense of the unity of the choice (restraint) of the environment to the system and the adaptation of the system to the environment. Therefore, the stability of the overall orderly structure of any system depends not only on the overall information network framework formed by the internal multilevel and complex information feedback loop but also on the support of the multiple and complex information feedback loop and related information network formed between the information network framework and the suitable open external environment conditions.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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