

## **EXPLORING SIMILARITIES BETWEEN GENERAL SYSTEMS: CONCEPTS, PROPERTIES AND IMPLICATIONS**

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### **Abstract**

Similarity phenomena are ubiquitous. From nature to social organizations, from biology to human behavior, various similarities exist. How should we define the essential similarity behind these phenomena? What are the properties of similarity? How to make use of similarity and what should be grasped in the application of similarity? Understanding similarity offers insights into both theoretical and practical aspects of systems. Exploring similarity helps us grasp universal principles and commonalities among different entities. Furthermore, examining similarities across different systems can yield valuable insights and experiences, facilitating system regulation from a similarity-based perspective. Therefore, studying the similarity behind phenomena not only deepens our understanding of the world but also offers critical support and guidance for solving practical problems. Similarity refers to the comparative relationship attribute where two or more entities exhibit a certain degree of likeness in specific aspects (attributes or laws). The denotation of similarity can encompass entities and phenomena across all fields and levels of both natural and artificial systems. Similarity is characterized by systematicity, comparability, hierarchy, degree, dynamism, adaptability, causality, and relativity. This study proposes regulating systems from a similarity perspective, controlling the degree of similarity to ensure that system structures and functions meet expectations, which provides significant insights. Finally, this paper presents application studies of system similarity in multiple fields. Overall, this study helps reveal the universal principles and fundamental laws of similarity between general systems, promoting the interdisciplinary development of system science and the application and practice of solving complex problems.

### **Keywords**

Similarity, Properties of Similarity, General Systems, Similar Systems, Complexity

### **1 | Introduction**

The similarity phenomenon is ubiquitous in both nature and human society. Examples include similar population structures in different ecosystems, similar management models in different enterprises, and similar policies among different countries. On a deeper level, observing the development of systems theory and the progress of modern science and technology reveals a universal phenomenon: similarities between extensively evolved systems, such as those between different biological systems and different engineering systems (Zhou, 1994).

System science has developed two main research approaches regarding this similarity phenomenon. The first approach involves studying the principles or laws of system universality from the perspective of system isomorphy. For instance, Bertalanffy proposed general system theory, describing the universal laws and principles present in general systems (Bertalanffy, 1968). Miller's Living Systems Theory summarized seven system levels, 20 subsystem classifications, and 173 cross-level hypotheses (Miller, 1978). Tromcale proposed 100 systems isomorphies as a basis for the classification and application of systems knowledge in systems processes (Troncale, 2006).

The second approach treats the similarity between systems itself as the research object, exploring the properties and significance of this abstract concept. For example, Tversky pointed out that studying the similarity between things is a feature-matching process, proposing a new set-theoretical approach to

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describe similarity, where things are seen as sets composed of their features (Tversky, 1977). Zhou's Similar Systems Theory mainly explores the role and application of similarity in systems (Zhou, 1994). Any system is composed of certain elements, and the system is the whole of its constituent elements. When different elements share certain common features, they are similar elements. From the perspective of the whole system, when different systems have similar elements, the systems themselves form a similarity, making them similar systems (Zhou, 1994). Liu and Wang proposed a similarity hierarchy in complex systems, indicating that similar systems have system hierarchy: the top level is overall system similarity, the bottom level is element similarity, and the intermediate levels are subsystem similarities (Liu & Wang, 2009). Additionally, typical theories constructed with similarity as the research object include the similarity theorems in the fields of physics and engineering technology (Buckingham, 1914; Kirpichev, 1955), the fractal theory in the field of mathematics (Mandelbrot, 1982), and the fractal enterprise theory developed in the management field based on fractal theory (Warnecke, 1993).

The research between these two approaches differs. The former is based on the premise or assumption of system isomorphy, focusing on developing principles or laws applicable to various types of systems. The latter investigates the basic concept of similarity between systems, which essentially represents a comparative relationship. Through comparing two or more systems, the degree of similarity between them can be determined. Although Bertalanffy's system isomorphy essentially reflects the similarity between systems, his research was not on similarity itself but on universal principles between systems based on this premise. Nonetheless, the pursuit of generality in systems theory also embodies this generality in similarity, as Bertalanffy suggested, discovering isomorphy among various systems. In this sense, researching system similarity and isomorphy are closely linked and may overlap in some aspects, though the direct objects and focuses of study differ. It is possible that in the near future, the research from these two approaches will converge, forming a more comprehensive and holistic field of study.

Research on system similarity holds significant value. Theoretically, grasping system isomorphy and general systems theory from the fundamental concept of similarity may create new system theories. Viewing the ubiquitous similarity relationships between systems can help construct new theories about system generation, evolution, and management. Practically, understanding the comparative relationships between systems from a similarity perspective aids in regulating the interactions between systems and influencing system outcomes. For example, Melamed et al. discovered through web-based experiments and agent-based models that similarity in social networks promotes social cooperation (Melamed et al., 2020). Ertug et al. conducted a systematic literature review on the outcomes of similarity, indicating that the consequences of similarity are studied at individual, dyadic, team, organizational, and macro levels (Ertug et al., 2022).

Given the extensive presence and descriptions of similarity phenomena and their profound impact on human understanding, utilization, and transformation of the objective world, the significance of similarity is undeniable. However, existing knowledge of similarity phenomena and similarity in different fields has yet to find a unified concept of similarity applicable broadly. Direct research on similarity as the primary object in system theory is still rare. Therefore, this study focuses on the similarity between systems, aiming to define the concept of similarity across various interdisciplinary fields and explore its properties. Finally, we summarize potential applications of similarity and present our applied research on system similarity. This paper is a foundational study on system similarity, and further research is needed to explore how similarity can play a more significant role in system science.

## 2 | Concepts of Similarity

What is similarity? What aspects does similarity encompass? These questions have been discussed in various fields (system science, cognitive science, philosophy) both directly and indirectly. The current definitions of similarity can be primarily divided into two schools of thought: the ontological school (Goldstone, 1996; Zhou, 1994, 1999; Zhang, 1992; Liang, 1999; Wei & Zeng, 1995) and the epistemological school (Goldstone & Medin, 1994; Medin, Goldstone, & Gentner, 1993; Tversky, 1977). The ontological school posits that similarity is an objectively existing relationship between systems. Due to the objectivity of attributes and properties within systems, similarity exists independently of human

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perception (Zhou, 2004). In contrast, the epistemological school defines similarity from the perspective of human recognition and understanding. Exhibit 1 lists the literature on the definitions of similarity.

The main viewpoint of the ontological school is that similarity pertains to the overall likeness of systems, specifically reflected in the similarity of their structure and function, as well as the similarity of elements and their properties. This similarity is evident at various levels within and between systems. Furthermore, similarity is not an absolute sameness but a relative sameness, representing a dialectical unity of sameness and difference. The epistemological school, on the other hand, focuses on how similarity is perceived and discovered by people. They argue that similarity is revealed through the process of comparison; it is through comparison that we determine whether things are similar. Similar to the ontological school, the epistemological school also believes that similarity is a relative concept of sameness.

**Exhibit 1.** Literature on the definitions of similarity.

Authors	Ontology/Epistemology	Definitions	Properties
(Zhou, 1994)	Ontology	Similarity as the resemblance between system components and their attributes.	Systematicity
(Zhang, 1992)	Ontology	Similarity as the dialectical unity of sameness and difference in objective reality.	Relativity
(Liang, 1999)	Ontology	Similarity relationships can be understood as corresponding relationships between entities in certain aspects, such as correspondences between parts, features, structures, or functions.	Hierarchy
(Wei & Zeng, 1995)	Ontology	Similarity reflects the commonalities in the structure, function, mode of existence, and evolution process of systems, manifesting as a differentiated commonality and a form of system unity.	Relativity
(Goldstone, 1996)	Ontology	Similarity depends not only on the number of shared features but also on the consistency and coherence of these features within the overall structure.	Systematicity
(Tversky, 1977)	Epistemology	Similarity is described as a feature matching process, specifically as a linear combination of the measures of their common and unique features.	Relativity
(Medin et al., 1993)	Epistemology	The manifestation of similarity is determined through the comparison process within the system to identify the aspects of similarity.	Comparability
(Goldstone & Medin, 1994)	Epistemology	Similarity involves establishing a correspondence relationship between two entities, where the process of establishing similarity is a process of comparison.	Comparability

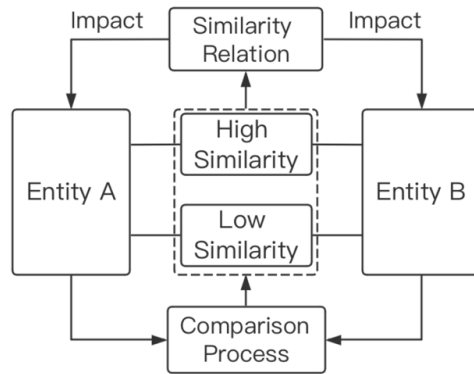
Integrating the definitions from the aforementioned researchers, this study provides a broader definition of similarity.

*Similarity refers to the comparative relationship attribute where two or more entities exhibit a certain degree of likeness in specific aspects (attributes or laws).*

This definition of similarity possesses both systematicity and interdisciplinarity. Systematicity is reflected in the belief that similarity describes a relational attribute existing between entities (systems). Interdisciplinarity is evident in that this definition does not confine similarity to a single discipline but applies it as a universal definition in both natural and social sciences. Therefore, the denotation of similarity can encompass entities and phenomena across various fields and levels of natural and artificial systems. The category of similarity includes both tangible similarity in entities and relational similarity (Wei & Zeng, 1995). Thus, similarity can be not only the visible geometric similarity but also the intangible functional similarity. Similarity in system laws, cognitive activities, and relationships are examples of relational similarity. Exhibit 2 presents the conceptual model of similarity constructed in this study.

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**Exhibit 2.** Conceptual model of similarity.



The concept of similarity defined in this study emphasizes three key aspects:

**Similarity as a Comparative Relationship Attribute.** Similarity essentially represents a comparative relationship attribute, depicting the comparative relationships between entities and revealing their common attributes or laws. This similarity is not just a characteristic of individual entities but a relational attribute between entities. When we say two entities are similar, we imply that they share certain commonalities, possibly in structure, function, or other aspects. The existence of this similarity allows us to compare, classify, and generalize entities, thus better understanding their nature and characteristics.

**Variability in the Degree of Similarity.** The degree of similarity between entities varies, reflecting the strength of the similarity relationship. Some entities may be very similar in certain aspects while markedly different in others. The degree of similarity can be measured and evaluated through various methods, such as quantitative analysis or qualitative comparison. This variability in the degree of similarity enables us to understand the comparative relationships between entities more comprehensively, recognizing both their similarities and differences, thereby promoting a deeper understanding of their characteristics.

**Substantive Role of Similarity.** The presence of similarity is not merely descriptive but also has substantive implications. Similarity between entities can regulate various interactions and influences, affecting their structure, function, and behavior. For instance, two similar systems may learn from each other, becoming more alike and influencing each other's evolution. Therefore, similarity is not only a descriptive relational attribute but also one with substantive impact, crucial for understanding the relationships between entities and the evolutionary processes of systems.

### 3 | Properties of Similarity

As a crucial concept in the field of system research, similarity possesses multiple properties, including systematicity, comparability, hierarchy, degree, dynamism, adaptability, causality, and relativity. These properties reveal the nature of similarity from different perspectives, providing a fundamental theoretical and methodological framework for understanding the relationships and evolutionary patterns among systems.

#### 3.1 | Systematicity of Similarity

Systematicity in similarity refers to the overall similarity at the system level, encompassing not only the similarity of individual elements or attributes but also the structural and functional similarities of the system as a whole. This holistic similarity is typically reflected in the interaction patterns among elements, the organizational structure, and the behavioral characteristics of the system. Goldstone's Alignment-Based Model of Similarity emphasizes that similarity depends not only on the number of shared features but also on the consistency and coordination of these features within the overall structure (Goldstone, 1996). In essence, even if a new similar feature is introduced, if it disrupts the existing alignment and consistency of

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features, the overall similarity decreases. This view aligns with the concept of systematicity discussed in this study.

The most significant manifestation of systematicity in similarity is system isomorphism. There are common principles and laws among systems (Bertalanffy, 1968), fundamentally reflecting the systematicity of similarity. From a compositional perspective, a system is an organic whole formed by its components and the relationships (connections) between them. Overall, a system consists of elements and relationships. The similarity of elements, termed “hard similarity,” is denoted by the letter ‘a’, while the similarity of relationships, termed “soft similarity,” is denoted by the letter ‘b’. Hard similarity refers to the similarity of individual elements within the system, including their properties, attributes, and roles within the system. For example, if two biological systems have similar cell structures, they exhibit hard similarity at the cellular level. Soft similarity refers to the similarity of relationships between elements within the system, including interaction patterns, connection methods, and dependencies. For example, if two social systems have similar social structures and interpersonal relationship patterns, they exhibit soft similarity at the relational level.

To more precisely describe system similarity, mathematical models can be utilized. Suppose the similarity  $\text{Sim}$  between systems A and B can be represented by hard similarity  $a$  and soft similarity  $b$ , we can use a function  $f$  to describe it. Equation (1) is shown below.

$$\text{Sim}(A, B) = f(a, b) \quad (1)$$

Here,  $f$  is a function that combines hard and soft similarity, with its specific form defined based on research needs, such as using weighted averages or other statistical methods to integrate the effects of hard and soft similarities.

### 3.2 | Comparability of Similarity

The comparability of similarity emphasizes that similarity is derived from comparing the similarities and differences between entities. Similarity, or the similarity relationship, describes the tendency of entities to be alike through the comparison process. This notion aligns with Medin et al.’s definition of similarity (Medin et al., 1993). Additionally, comparability highlights the dependency of similarity. Without comparison, similarity would not be recognized, as it is relative to a certain standard or reference (Tversky, 1977). Once a comparison is made, similarity becomes apparent, whether the comparison is between existing entities, between existing and virtual objects, or even between virtual objects. For instance, in the process of goal setting and performance evaluation, the operational status of a system and potential improvement areas can be assessed by comparing achieved outcomes with anticipated ones. From a perspective of similarity, the essence of goal management lies in regulating the similarity between actual and expected outcomes, which managers need to progressively increase. A higher degree of similarity indicates a greater degree of goal achievement. This virtual comparative approach provides valuable insights for assessing and optimizing system performance. It is important to note that similarity is an inherent attribute of objects and remains unchanged by human will. The process of comparison merely serves as a mechanism for discovering similarity rather than creating it.

In practice, similarity comparisons can occur at multiple levels and dimensions. For instance, comparisons can be made regarding structure, function, and behavior of systems, or regarding the similarity of systems at different time points or under different environmental conditions. This diversity in comparison provides rich avenues and methods for analyzing and identifying similarities.

### 3.3 | Hierarchy of Similarity

The hierarchical nature of similarity underscores that similarity exists at various levels within a system. In general systems theory, systems are decomposed into different levels, each with relatively independent structures and functions (Bertalanffy, 1968). Similarity analysis is conducted at specific system levels (Zhou, 2004). Similarity between main systems is termed hetero-similarity, reflecting commonalities between different main systems. For example, different companies may share similar organizational

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structures and business models, which are hetero-similarities indicating shared characteristics and behavioral patterns among companies. Besides hetero-similarity, there is also self-similarity between a main system and its subsystems. Subsystems, as components of the main system, may exhibit similarities in structure and function to the main system. For instance, the goals of subsidiaries often align with the overall strategic goals of the parent group, reflecting self-similarity.

Building on classical similarity theory, the concept of similarity in complex systems further expands the notions of local and global similarity and proposes the hierarchy of system similarity (Liu & Wang, 2009). System similarity hierarchy indicates that similar systems possess hierarchical levels, with the highest level being overall system similarity, the lowest level being element similarity, and intermediate levels being subsystem similarity. Liang interprets similarity relations as corresponding relationships in certain aspects, such as features, parts, structures, and functions (Liang, 1999). This correspondence is hierarchical, representing one-to-one correspondences at different levels between systems.

The hierarchy of similarity reflects the stratified characteristics of system structure and organization, unveiling the intrinsic connections and interactions across different levels within systems. This hierarchical similarity aids in understanding the organizational and evolutionary patterns within systems and provides guidance for system design and optimization.

### 3.4 | Degree of Similarity

The degree of similarity emphasizes that similarity varies in strength, indicating that the level of similarity can be high or low. Usually, systems of the same type exhibit a higher degree of similarity; for example, organisms of the same species tend to have higher similarity, sharing many similar aspects. Conversely, systems of different types often exhibit a lower degree of similarity; for instance, inorganic systems and organic systems often show very little similarity, to the point of being considered dissimilar (Wei & Zeng, 1995).

The degree of similarity is a crucial handle for analyzing and utilizing similarity. By understanding the degree of similarity, we can measure its magnitude and then regulate it to meet specific expectations. Research on methods for measuring similarity spans multiple fields, including e-commerce, social networks, expert systems, data mining, and decision support systems (Hung & Hoi, 2015). Nikfalazar et al. proposed a new method based on fuzzy number similarity for fuzzy risk analysis (Nikfalazar, Khorshidi, & Hamadani, 2016). Kim et al. developed a similarity measure based on distance metrics for fault detection technologies (Kim, Lee, & Wang, 2009). Hung and Hoi proposed a general similarity measure model based on object attributes, demonstrating its application in social networks and e-commerce (Hung & Hoi, 2015). These studies illustrate the wide application and importance of similarity measurement methods in various fields, enhancing the accuracy and practicality of similarity assessment through multiple criteria and models.

### 3.5 | Dynamism of Similarity

Systems are in a state of dynamic change, and it is the evolution of systems that causes the evolution of similarity between different systems (Zhou, 2004). The dynamism of similarity indicates that similarity between entities is not static but is subject to dynamic change, involving alterations in external environments, changes in internal elements, and interactions between the two. Systems are viewed as wholes undergoing dynamic evolutionary processes, continuously influenced and adjusted by external environments and internal elements (Bertalanffy, 1968). Consequently, the similarity between systems changes over time and conditions, reflecting a dynamic characteristic.

Changes in the external environment are a significant factor affecting the dynamism of similarity. As the environment changes, the external conditions and constraints of the system also change, leading to adjustments and reconfigurations in the system's internal structure and function. Such environmental changes may cause originally similar systems to diverge or previously dissimilar systems to converge. Additionally, changes in internal elements also impact the dynamic changes in similarity. Interactions and feedback among internal elements lead to changes in system structure and behavior, influencing the degree of similarity between systems. Adjustments and changes in internal elements may cause originally similar systems to become increasingly different or previously dissimilar systems to become more alike.

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The changes in external environment and internal elements are usually interrelated and interactive. Environmental changes may trigger adjustments and changes in internal elements, while changes in internal elements can, in turn, affect the system's adaptation and response to the external environment. This interaction between environment and internal elements adds complexity and richness to the study of dynamic similarity. Investigating the dynamism of similarity between systems aids in understanding the evolutionary and changing patterns of systems and provides theoretical support for the dynamic adjustment and optimization of relationships between systems.

### 3.6 | Adaptability of Similarity

Adaptability of similarity emphasizes that changes in the degree of similarity between entities are made to adapt to the environment. This property reveals the intrinsic relationship between dynamic changes in similarity and environmental adaptation. In general systems theory, a system is viewed as a continuously evolving and changing whole, influenced and regulated by both external environments and internal elements. To adapt to ever-changing environmental conditions, a system's internal structure and functions will also undergo corresponding adjustments and changes, resulting in variations in similarity (Zhou, 2004). Holland formally introduced the concept of complex adaptive systems in 1992 and proposed the famous idea that "adaptation creates complexity" (Holland, 1992). Such adaptive changes often lead to changes in the degree of similarity between systems and their subsystems or between different systems. Therefore, from the perspective of similarity, we can say that the adaptive changes in similarity create complexity.

Adaptability of similarity emphasizes that changes in the degree of similarity result from adapting to environmental changes. Systems adjust their structures and functions to better match and coordinate with the environment, thereby improving their survival and competitive capabilities. This adaptive change is one of the key driving forces behind system evolution and development and is also one of the reasons for the emergence of complexity. The complexity caused by changes in similarity manifests mainly in two aspects. Firstly, adjustments in the internal structure and functions of a system may change the degree of similarity between the system and other systems, thereby increasing the complexity of inter-system relationships. Secondly, to adapt to constantly changing environmental conditions, a system may need to diversify its internal adjustments and changes, leading to increased internal complexity. Therefore, we believe that the adaptive changes in similarity are an important factor in creating system complexity.

### 3.7 | Causality of Similarity

Causality of similarity is an important property of the similarity concept, emphasizing the causal relationships between similarity and other entities. Specifically, similarity can be both an effect, caused by other relationships, and a cause, leading to changes in other aspects of similar entities.

As an effect, similarity can be directly or indirectly caused by other relationships. For example, the cooperative relationship between two organizations may increase their similarity, as cooperation encourages the sharing of experiences and learning from each other's practices, leading to increased similarity. This formation and evolution of similarity as an effect reflect the causal relationship between similarity and external interactions. Organizational isomorphism is a typical example of similarity as an effect. The three mechanisms of organizational isomorphism result from external interactions leading to organizational convergence (DiMaggio & Powell, 1983; Scott, 2013).

As a cause, changes in similarity can affect other aspects of similar entities. For instance, an increase in similarity between two organizations indicates enhanced consistency in their culture and management styles, subsequently influencing their cooperation performance and organizational effectiveness. This change in similarity as a cause highlights its impact on other aspects, demonstrating the causal relationship between similarity and other entities. Empirical studies show that racial similarity affects team supportive relationships, with increased diversity leading to a decline in supportive relationships (Bacharach, Bamberger, & Vashdi, 2005). In multinational companies, similarity in nationality, culture, language, and organizational status promotes knowledge sharing but may also lead to group cohesion, hindering inter-group knowledge flow (Makela, Kalla, & Piekkari, 2007).

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Thus, causality of similarity underscores both the formation process of similarity as an effect, influenced by other relationships, and the role of similarity as a cause, impacting other entities. Understanding this causal relationship provides a more comprehensive understanding and description of the similarity concept, offering deeper insights for similarity research.

### 3.8 | Relativity of Similarity

Relativity of similarity reflects the unity of opposites between similarity and difference (Zhang, 1992; Wei & Zeng, 1995), showcasing the commonalities and differences in the attributes and characteristics of specific entities (Zhou, 2004). Differences are absolute, while similarity is relative. Similarity exists only when differences in the considered aspects are secondary, allowing for a dominant commonality between systems. In other words, system similarity is not absolute identity but rather a manifestation of relative identity on specific dimensions where differences are minimal, and similarity is predominant. Even though two systems may have significant differences in specific details, the focus in research and analysis is on those aspects that exhibit similarity, where the differences are relatively minor, thus presenting relative identity in these aspects. Tversky's feature similarity theory posits that similarity is a linear combination of common and unique features (Tversky, 1977). This linear combination incorporates both the similarities and differences of the system, representing the dialectical unity of sameness and difference.

This relative similarity emphasizes the flexibility and context-dependency of system analysis and research. Each system may exhibit different degrees of similarity and difference on various dimensions. For example, in ecological research, two ecosystems might have significant differences in species composition but exhibit high similarity in ecological functions, energy flow, and material cycling patterns. Similarly, in business management, different companies might differ in organizational structure and culture but share similarities in business processes, management methods, and market strategies. The unity of similarity and difference implies that researchers need to clarify the dimensions and criteria of comparison in a specific analytical context and identify the similarity between systems based on these criteria.

## 4 | Applications of Similarity

### 4.1 | Implications

The study of similarity aims to clarify its concept, establish theoretical frameworks related to similarity, seek a unified understanding of the numerous similarities present in nature, society, engineering, and cognition, elucidate the principles and evolution of similarity, and explore the laws of system similarity and their applications. This paper presents the concept of similarity and its eight properties, which aid in understanding, analyzing, and promoting the development of theories and methods related to system similarity. The focus of system similarity research lies in theoretically understanding and analyzing similarity and practically applying and creating similarity (Zhou, 2004). The study of similarity is interdisciplinary, as similar phenomena appear in almost all fields. Similarity research aims to explore the essential similarities behind these phenomena and how to utilize this similarity to align developments with human expectations. Therefore, the applications of similarity are widespread across various disciplines, demonstrating significant flexibility. Theoretical research on similarity is abstract, fundamental, and theoretical, requiring application research and theoretical validation in specific disciplines and problems.

The most crucial aspect of applying similarity is to identify, grasp, and regulate similarity between specific similar systems, thereby influencing the system's structure and function to meet desired outcomes. Identifying, grasping, and regulating similarity requires both theoretical guidance and practical flexibility. The essence of similarity application lies in controlling the degree of system similarity. The similarity between systems should not be maximized (convergence) or minimized (divergence) arbitrarily. Instead, the similarity should optimally fit the expected structure and function of the system. This is a dynamic balancing process, where short-term fluctuations in similarity might occur, but over the long term, the system's similarity should stabilize at an appropriate level that ensures the system's structure and function meet expectations.

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### 4.2 | Applications

Our team has conducted application research on system similarity in various fields. In the field of education management, Dang studied the similarity of undergraduate teaching systems, viewing these systems as composed of similar subsystems of students and teachers, aiming to improve teaching efficiency by examining the similarity from superficial phenomena to underlying mechanisms and management strategies (Dang, 2023). In process management, Xie used similarity theory to construct a goal-oriented enterprise process model, analyzing the characteristics of enterprise processes and their elements, exploring the formation and evolution mechanisms of process similarity, and proposing management strategies to scientifically guide enterprise process design choices (Xie, 2023). In the field of safety risk, Sun focused on the similarity risks of the external environment along high-speed rail lines, analyzing similar elements from a system perspective, exploring the formation mechanisms of similar risks, and proposing prevention mechanisms to prevent the recurrence of similar risks (Sun, 2022). In industrial integration, Wang dissected the value co-creation logic between advanced manufacturing and modern services, dividing specific value co-creation behaviors into matching and grafting steps. Matching behavior relies on the similarity between industrial entities, while grafting behavior relies on their complementary characteristics (Wang, 2023). In enterprise management and complexity, Xu studied fractal self-similarity theory to understand complex enterprise systems, constructing hierarchical network models to analyze enterprise complexity and the relationship between self-similarity and complexity, and designed self-similarity within enterprises to regulate complexity (Xu, 2019).

Furthermore, many scholars have applied the similar systems theory in their specialized fields. For example, in the pharmaceutical domain, this theory can be used to quantitatively assess the similarity of nonlinear chemical (NLC) fingerprints of traditional Chinese medicines (TCMs). This method is superior to Euclidean distance, correlation coefficient, and cosine similarity as it can quickly and accurately distinguish and evaluate the NLC fingerprints of TCMs, faithfully reflecting sample differences (Zhou et al., 2011). These examples demonstrate the wide applicability and promising prospects of similarity research in various fields.

### 4.3 | Limitations and Future Studies

Since this paper is a preliminary study, it has many limitations. Firstly, the provided definition of similarity is broad, and further research is needed to refine the aspects of similarity based on specific issues. Secondly, the eight properties proposed may not be exhaustive, and further studies are required to supplement them. The accuracy of these properties also needs further validation. Thirdly, this paper only provides the concepts, properties, and applications of similarity, serving as a basic theoretical study. Future work should build a comprehensive theory of system similarity and test its validity in practical applications to improve the theoretical framework of system similarity research.

## 5 | Conclusion

This study is an exploratory foundational research on similarity, primarily involving its concept, properties, and applications. The paper defines similarity as a comparative relationship attribute where two or more entities exhibit a certain degree of likeness in specific aspects (attributes or laws). The scope of similarity can encompass various fields and levels of both natural and artificial systems. Additionally, this research summarizes eight properties of similarity: systemicity, comparability, hierarchy, dynamism, adaptability, degree, causality, and relativity. Understanding these properties helps in analyzing and applying similarity. Finally, the study explains the value of similarity applications, key points, and provides illustrative examples. It offers researchers insightful thoughts and future research directions for analyzing and applying similarity, promoting the development of similarity theory and its applications.

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