Properties of the physical space, the information space and out-structure space of information

Sha Li¹, Weiwei Du², and Zhisen Wang*¹

¹ Information Science and Engineering, Dalian Polytechnic University, Dalian, Liaoning, 116034, China
² Information Science and Engineering, Dalian Polytechnic University, Dalian, Liaoning, 116034, China
*Corresponding author’s e-mail: z_s_wang@dlpu.edu.cn

Abstract. Human beings live in the physical space, think and judge in the information space, and act back in the physical space. Their thinking and judgment greatly depend on information accumulation and the environmental stimulation in their physical spaces. Therefore, their cognition and actions are formed under the guidance of both the physical space and information space. Based on the three-element engineering model, this paper takes the present characteristics of time to reinterpret the properties and relationships among the physical space, information space and out-structure space of information. The findings of this analysis are intended to provide a precise guide for people on their individual or collective life in society, especially as a result of the increasing nature of information processing ability in the present era. As well, the findings of this study are anticipated to provide some guidance for people’s thoughts concerning the developing society, which they can use to understand the anticipated nature of society in the future.

1. Introduction

Material is often used as a general term for the elements of all observable objects [1-2]. Material can also denote an objective or physical existence. Information is a set of material’s attributes and laws, meaning that there is no material without information. In an objective world, material exists in the physical space in the form of a physical entity. As well, information exists in the information space in the form of an information entity. Information also exists symmetrically with physical entities [3], meaning that the physical and information spaces are mutually independent (see Figure 1).

Media is the carrier of information wherein physical entities are the basic media of information entities. In the three-element engineering model [4], the observer can out-structure a part of the information entities in its storage media. With the continual process of human evolution, people have become the best observers. The human brain has an independent self-consciousness. It acts as the main undertaker of out-structure of information, and links the out-structure space of information with the physical-information space. In this paper, the discussion about the observer is aimed at human beings.

Based on the understanding of the basic concepts of material, information, physical entities and information entities, and based on the three-element engineering model, this paper studies the properties and relationships among the physical space, information space and out-structure space of information. The study is intended to re-examine the evolution of social process in the digital age from the information theory perspective.
2. Physical space
In the long process of evolution, human beings first perceived the existence of physical space. From the standpoint of human beings, the evolution of physical space looks like a natural cycle. All the time, space, seasons and measurement units are established by human beings, and then gradually develop with the change of the cycle. Finally, become the existence of truth which tends to be normative. People discover the internal development laws of things, and establish autognosis in the ever-changing external environment. And the improvement of human cognitive abilities has impact on the external environment of life, leading to changes in the natural physical space. It can be said that humans coexist with the physical space and evolve synchronously over time with it.

Proposition one (the existential proposition of the physical space): Physical space is the place where physical entities exist. Physical space and physical entities exist objectively. Physical entities are the basis for the existence of material. They have both exclusivity and multidimensional scales of time and space. Besides, dimensions as well as the scales on dimensions are the frame of reference to observe entities. The existence of physical entities must occupy a unique physical space, thus guaranteeing the uniqueness of physical space.

Axiom one (the basic axiom of physical space): Time and space is the basic dimension of physical space. The existence of physical entities occupies a unique time and space. The characteristics of time and space is the basis for the existence of physical entities, and is also the basic dimension of physical space. Based on this axiom, the property of physical space can be deduced as follows:

Property one: The incompressibility of the physical space. The time-space exclusivity of physical entities leads to the uniqueness of physical space. Physical entities have their life cycles. In order to adapt to the phased changes of natural physical cycle, within a certain period of time, physical entities cannot be completely copied in physical space, nor can they be reproduced or compressed. And this property explains the saying “there are no two identical leaves in the world”.

Property two: The physical space can be added.

$$ P_S = \sum_{i=1}^{n} P_{Si} $$

In equation 1, $P_{Si}$ represents an individual physical space, and $P_S$ represents a set of individual physical spaces. Physical spaces are mutually independent, ensuring the inter-individual additivity in their own spaces.

3. Information space
Information space is a mirror image of physical space, and is also a place to store information entities. Information entities describe the properties of physical entities. As a physical entity, all human
consciousness, form and memory are stored in the corresponding information space. The information spaces corresponding to different information entities which are relatively independent.

Proposition two (the existential proposition of the information space): Information space is a place where information entities exist. Physical entities exist, and the corresponding information entities also exist objectively. Information entities record the static and dynamic properties of physical entities, and their existence has to rely on physical entities, which is to say, they cannot be separate and exist from entities alone. Human beings cannot directly understand the objective existence of information entities which can only be recognized and applied through the reflection of observers.

Axiom two: Information space symmetrically exists with physical space. Physical space and information space have objectively-existing biological attributes. Information entities represent the properties of physical entities. There are no such information entities existing out of physical entities. For example, information space contains the collection of all the properties about entities (including composition, shape, geographical location, etc.). Human beings can only abstractly perceive entities by means of vision, hearing, touch and so on. It can be said that physical entity and information entity are strictly symmetrical and synchronized. Therefore, the information space and physical space of the storage entities, are also symmetrical, and these two spaces are orthogonal.

Hence, the basic properties can be deduced as follows:

Property one: The incompressibility of information entities in the same space.

Property two: The collection of information space can be added.

\[ I_S = \bigcup_{i=1}^{n} I_{SI} \]  

In the equation 2, \( I_{SI} \) represents an individual information space, and \( I_S \) represents a collection of individual spaces. Information space can be added in collection, in which the amount of information can be gradually covered with the extension of entity capabilities. Besides, the transitivity of information entities is dependent on the physical translational speed of physical entities. Finally, Information life can be inherited on the long time scale.

4. **Out-structure space of information**

Out-structure space of information is the place where observers map information entities from physical entities with their own out-structure capabilities and store the out-structure information [3]. For example, books, newspapers, the Internet and so on. These are the out-structure media where human beings use to store information. Out-structure space of information is not established by any country, company or individual, but a space collectively established by all observers. The human brain is the earliest out-structure space of information, which has many information properties like encoding and storage, as well as the physical properties like cognition and perception. The inter-individual in out-structure space of information of human beings comprises the most typical information island.

With the continuous development of communication and the Internet, the information utilization of observers has been greatly improved. And it accelerates the convergence of individual out-structure information, which not only expands the field of information interaction, but also realizes human judgment of local information under the overall cognition.

4.1 **Observers**

Proposition three (the existential proposition of out-structure space of information): Out-structure space of information exists independently based on observers. There is no self-diffusion property in the objective existence of physical and information space which can only be commonly recognized through observers. Human beings are the best observer, as humans can not only rely on their natural organs, but also expand their perception by making and using tools. The action of thinking and judging in human brains are the first out-structure media of information entities. And the out-structure information in the brains stored in books, USB flash disks and other secondary media through coding, finally forming the second out-structure media. The spread of out-structure information gives rise to multiple out-structure
media, thus forming the public out-structure space of information (see Figure 2). Therefore, observers are the bond linking the out-structure space of information and the physical-information space.

Figure 2. An abridged general view of the information out-structuring process of observers.

**Axiom three: Out-structure space of information is smaller than information space.**

\[ I_{\text{od}}(x_a, y_b, z_c) < I_S(x_a, y_b, z_c) \]  

In inequality 3, \( I_{\text{od}}(x_a, y_b, z_c) \) represents the out-structure space of information of observers, and \( I_S(x_a, y_b, z_c) \) represents the information space of observers.

Compared to information space, out-structure space of information will often be limited by the social experience and thinking mode of observers, thus resulting in the distortion of information space during the process of out-structure. The emergence of secondary media expands the ways in which observers observe the world. Human beings can get instant information or accumulate information anywhere and anytime through radio, books or the Internet, which improves the efficiency of human understanding of the world and prolongs their information life. Table 1 has briefly listed the properties of physical space, information space and out-structure space of information.

| Categories              | Physical space | Information space | Out-structure space of information |
|-------------------------|----------------|-------------------|-----------------------------------|
| Existence properties    | Temporal existence | A mirror image of physical space | Relying on observers (humans)     |
| Storage properties      | Incompressible  | Incompressible    | Compressible                      |
| Periodic properties     | Finiteness      | Finiteness        | Infinity                          |

4.2 The property of out-structure space of information

Axiom four (the basic axiom of out-structure space of information): Out-structure space of information could be compressed into a point in physical space.

The high speed communication and Internet of things have not only broken the isolation of out-structure information, but also realized the integration of the Internet and human. It means that infinite extension of human out-structure capabilities in physical space. Every human can be a compressed point of physical entities. The more efficient compression algorithm enables us to process more information with the same amount of hardware [5]. And in the process of storage, disks, computers and other media of out-structure information will not be changed in physical forms due to the storage capacity. In the process of information out-structuring, there is no obvious regional concept for information flow and
interaction which neither is constrained by the boundary of physical space, nor occupy any physical space. Through analyses, some basic properties of out-structure space of information can be summarized as follows:

Property one: The physical connectivity of out-structure space of information is getting increasingly well.

Out-structure space of information has gradually broken the various obstacles in information dissemination. Human beings are gradually having a comprehensive understanding of entities. In the process of mobile communication moving from 1G to 5G, its influence has spread from daily life to network learning, visual communication and many other fields [6]. The coverage includes almost all human beings, giving rise to the interconnected situation of out-structure space of information, to some extent, preventing the emergence of digital divide.

Property two: The energy consumption of the information circulation in out-structure space of information is being continuously reduced.

The existence of human beings is accompanied by the existence of information. Throughout history, human exploration of information transmission has never stopped. From knot tying, carrier pigeons to printing, all these are aimed to enhance the efficiency of information transmission. But in the process, there are still some external factors disturbing the circulation of information. However, in the 21st-century out-structure space of information, human beings make the instant circulation of information possible through technologies and media. With the compressed time and space, the reduction of energy consumption results in the continuous reduction of production costs in the society.

Property three: Impacted by out-structure space of information, the information out-structuring capabilities of observers can be enhanced.

With the development of electronic information technology, the out-structure space of information gradually expands from the human brain to various electronic terminals. The popularization of the Internet also makes human beings closely linked with the out-structure space of information. As of June 2017, global Internet coverage reached more than 50% [7]. Out-structure space of information has gradually become an information infrastructure. In the context of the collective memory in the digital age, larger data samples are more conducive to tracking individual and collective events, which realizes the island judgment under the perfect information [8]. Based on this, mankind moves from isolation to integration, from decentralization to entirety, and the "integral value" in digital space is gradually emerging. They lead to the gradual increase in human's ability to deal with events, thus
accelerating the dynamic operation of the society (see Figure 3, OO.IS represents the single out-structure space of information). Therefore, observers are a kind of active individuals that are directly impacted by physical-information spaces and indirectly impacted by out-structure space of information.

At present, the out-structure space of information is rapidly expanding under the guidance of new information technologies, such as artificial intelligence, big data and cloud storage. But at the same time, it also causes people to ponder over the new norms of "security" and "sharing" [9-10]. Under the massive data samples of the Internet, how to effectively use the out-structure space of information to classify information, thus to identify the authenticity of information and not be kidnapped by information will be the next problem requiring further consideration.

5. Conclusion

Human evolution and development has come along with the development of information. Presently, people tend to neglect some of the frontal issues in the process of dealing with massive information. This has made people lack the right decision-making and insight abilities when faced with different social phenomena. In this paper, the understanding of the basic problems of physical space, information space and out-structure space of information will refer to the three-element engineering model to reconstruct a logical framework of human thinking. From the analysis, it will help to reinterpret the state of human existence under perfect information, thus providing feasible theoretical references to understand human social behaviour as well as social phenomena.

References
[1] R. Penrose. (1991) The mass of the classical vacuum. Oxford University Press, Oxford.
[2] M. Hill. (2009) Encyclopedia of Science and Technology Online. McGraw-Hill's Access Science, New York.
[3] Zhang Long, Liu Li, Du Weiwei, et al. (2016) Out-Structure of Information Based on the Perspective of Observer. Journal of The China Society for Scientific and Technical Information. 35(8):817-825.
[4] Zhang Long, Liu Li, Du Weiwei, et al. (2017) Investigating of information communication and information space from the perspective of observer. Journal of Dalian Polytechnic University. 36 (5) :380-385.
[5] Martin Hilbert, Priscila López. (2011) The World's Technological Capacity to Store, Communicate, and Compute Information. Science, 332:60.
[6] M. Hasan and E. Hossain. (2013) Random Access for Machine-to Machine Communication in LTE-Advanced Networks: Issuesand Approaches. IEEE Communication Magazine, 51(6):86-93.
[7] China Internet Information Center. (2017) Statistical report on the development of China's Internet Network. http://cnnic.cn/hlwfzyj/hlwxbzglhwjtb/201708/P020170807351923262153.pdf.
[8] R García Galvanes, A Mollgaard, M Tsvetkova, et al. (2017) The memory remains: Understanding collective memory in the digital age. Science Advances. Adv 3 (4):1-7.
[9] Joshua Cooper Ramo,(2007) The Seventh Sense - Power, Future, and Survival in the age of Networks. New York Times, New York.
[10] Karla L. Hahn. (2008) Sharing Data, Constructing Science. Science. 320(5880):1162-1163.