**The silent technological revolution in cognitive domain**

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Unknowingly, the Russian-Ukrainian conflict has lasted for more than 100 days. In this conflict, smart weapons and information systems such as drones, precision guidance, and satellite networking have appeared one after another, attracting the attention of global observers. At the same time, a "confrontation without gunpowder smoke" has also quietly unfolded. As a new space, the cognitive domain has entered the stage of military confrontation. Some experts predict that the cognitive warfare in the Russian-Ukrainian conflict, like the information warfare in the first Gulf War, will become a new engine driving the accelerated evolution of global high technology. What are the new characteristics of the cognitive domain compared to the physical domain and the information domain? How to achieve leapfrog innovation in cognitive domain engineering technology? With these questions, this newspaper reporter had a "dialogue across the air" with experts and professors from the Institute of Big Data of Fudan University, and jointly discussed the innovative path of paradigm change in cognitive domain engineering technology in a "brainstorming" session.

**The "third living space" of human beings is taking shape**

In the traditional sense, cognitive domain is a scientific and philosophical term, which refers to various cognitive activities such as human consciousness, thinking, and cognition, which are invisible and intangible. With the advancement of science and technology, cognitive domain is "as if it is with us". Although it is "invisible and intangible", it is also "indispensable and cannot be discarded". It seems invisible, but it actually exists.

Professor Zhao Xing from the Institute of Big Data at Fudan University pointed out that after physical space and cyberspace, humans are welcoming a new living space - "cognitive space", which is the "third living space" for our work and life. In the first two decades of this century, driven by the strong push of Internet technology, humans formed the "second living space" - cyberspace, a complex system world composed of carriers, information, users, interactions and applications. In this space, humans have created Internet civilization, realized digital survival, derived new formats and new models, and achieved a great leap in science and technology.

"In the next 20 years, humans are expected to open up another new living space," Professor Zhao Xing predicted. He pointed out that the "third living space" of humans is the world of thinking, cognitive space, or cognitive domain. The cognitive domain that appears as a living space is no longer a cognitive domain in the sense of scientific philosophy, but a virtual-real interactive space characterized by "integration of virtual and real, reflection of virtual with real, and virtuality for real". It is a new space where the subjective world and the objective world blend with each other. In this new space, humans communicate ideas, create knowledge, and emerge wisdom through new media and relying on new tools. They can even transcend the limitations of time and space to build a super-intelligent society with a high degree of integration of humans and machines, similar to the concept of "Society 5.0 " once proposed by Japan.

In cyberspace, people can achieve "what you see is what you get", and in cognitive space, people can achieve "what you think is what you get". Cognitive space will greatly break through the boundaries of human capabilities and vision, with artificial intelligence as the brain, robots as muscles and labor, big data as energy, and the Internet of Things as nerves. Various information will break through the barriers between the virtual world and the real world, and ultimately provide accurate and effective services for all mankind.

**Cross-domain linkage is the core feature of cognitive domain**

"Just as human thinking does not exist in isolation, the cognitive domain does not exist in isolation. The cognitive domain is a new system formed by cross-domain linkage." Zou Hong, deputy director of the Big Data Research Institute of Fudan University, believes that the core feature of the cognitive domain is the interweaving and cross-domain linkage of the "three domains" of physical domain, information domain, and cognitive domain.

"Physical-information-cognition" are intertwined and interlinked. In layman's terms, it is the fusion of "man-machine-object" or "man-network-object", which is mainly manifested in four characteristics. First, relative independence. Each field has its own characteristics and is a self-contained system. Strictly speaking, these are three parallel worlds with mutual mapping relationships. Second, extensive connectivity. The physical domain and the information domain are connected through the information-physical system, and the information domain and the cognitive domain are connected through the information-cognitive system. The three domains can also be connected to a larger extent through the information-society system, forming a large closed-loop system. Third, multi-directional transmission. Events in the physical domain may trigger events in the information domain or cognitive domain. For example, a major natural disaster may cause network communication failures or even partial network paralysis, which in turn may cause cognitive panic among people. For another example, some problems in the information domain may also be transmitted to the physical domain and cognitive domain. Fourth, risk superposition. The interweaving of the "three domains" is more likely to trigger the "butterfly effect". Often, a small problem that occurs in the real world and physical space will form a major turbulence in the cognitive domain through the "amplifier" and "multiplier" of cyberspace, which will eventually cause global shocks or even disasters in the entire social system. The deeper the interweaving of "physics-information-cognition", the greater the intensity of the risk outbreak.

"The cognitive domain itself is also a complex system composed of multiple subspaces," said Associate Professor Zheng Xiaoqing of Fudan University. "The cognitive domain of the cognitive subject can be further subdivided into the belief domain, the doubt domain, and the unknown domain. Although these three domains do not overlap, their propositional elements can be converted among the three domains, thus dynamically forming a cognitive subject's understanding of all logical connections in the world." What people are sure of is in the belief domain, what people do not know yet is in the unknown domain, and what is known but not sure is in the doubt domain. For example: For objects that people have not heard of or seen, its color is unknown to us. When someone tells us that it is red, we may still have doubts. When we have seen the object with our own eyes, we can be sure that it is red. But we are told that when we observe the object, it may be illuminated by red light. So, we begin to doubt whether it is really red, because any object illuminated by red light will look like red. People's cognition of a certain color may also be "twists and turns" under external intervention, and it is vast and unknowable.

One of the purposes of cognitive games is to transform the distribution of propositions in the unknown domain, doubt domain, and belief domain in the cognitive space of individuals or groups by effectively acquiring and transmitting information, thereby forming public beliefs. The interweaving of the three domains of "physics-information-cognition" and the three-way interaction of "belief-doubt-unknown" constitute the salient features of the cognitive domain.

**Cognitive domain technology faces “three major challenges”**

At present, our description of cognitive domain mostly stays at the level of qualitative analysis, which is what people often call "storytelling". As a new type of living space and technical form, cognitive domain has its unique technical attributes.

Professor Xue Xiangyang, deputy director of the Big Data Research Institute of Fudan University, believes that humans face at least "three major challenges" in the cognitive domain.

The first is the "barrier" of generalized functional safety. Against the backdrop of the interweaving of the three domains of "physics-information-cognition", the generalized functional safety problem of the cognitive domain has emerged. We know that there are some "innate defects" in human cognition, such as individual cognitive biases that cannot be eliminated and group cognitive polarization that is inevitable. Through research, it is found that these innate deficiencies can be intervened and utilized in certain ways, and even some kind of manipulation can be achieved. For example, the "information cocoon" and "echo chamber effect" phenomena that have emerged now. The superposition of cognitive functional safety issues and network security issues constitutes the generalized functional safety problem of the cognitive domain. The "generalized functional safety" problem is like an insurmountable cliff, lying across the process of deep integration of "man, machine and object". Without integration, there will be no technological progress; the deeper the integration, the greater the safety risk. Dilemma, dilemma.

The second is the "puzzle" of human cognition. What cannot be avoided in the cognitive domain is cognition. How does human cognition come about? This is still a difficult problem in the scientific community. People have established neuronal cell dynamics models based on easily observable quantities such as proteins, ion channels, chemical signals, and electrical signals, hoping to break through the problem of biological intelligence. The EU HBP project has invested a lot of money to scan slices of animal brains, obtain the topological connections of neurons in the whole brain, build a super-large-scale neuronal simulation platform, and finally restore the process of human cognition formation. However, these studies have not yet made any breakthrough progress.

The third is the "noise problem" of artificial intelligence's impact on human cognition. Big data and artificial intelligence technology have shown some new tendencies in their influence on human cognition due to their "inherent insecurity" problems such as unexplainability, unpredictability, and unreasonability. With the rapid advancement of artificial intelligence technology, more and more artificial intelligence systems have passed the Turing test. The posts, pictures, music, and short videos that people see on social networks may be automatically generated by intelligent systems. The biggest problem with the various information we see on the Internet is that it is difficult to distinguish between true and false. What you see may not be true, what you hear may not be true, and there may not be truth in pictures. People cannot verify the authenticity of each piece of information. Deep learning-based deep fake technology has begun to generate a large amount of "noise" beyond human imagination, and its impact on human cognition has become increasingly greater, and will even subvert the traditional human cognitive model.

The cognitive domain is a brand new field. Every change in cognitive domain engineering technology will profoundly change human beings themselves and will inevitably change society.

**Achieving a new leap with a new paradigm**

If we want to seize the initiative in cognitive domain technology innovation, we must promote paradigm change, use new paradigms to achieve new breakthroughs, and take a unique and innovative new path. Academician Wu Jiangxing of the Chinese Academy of Engineering was the first to propose the need to achieve paradigm change in cognitive domain engineering technology and seek new breakthroughs in cognitive domain technology by building a new paradigm.

Academician Wu Jiangxing of the Chinese Academy of Engineering said that the paradigm shift was first proposed by Kuhn, triggering a series of thoughts on the scientific and technological revolution. Paradigm shifts generally include three levels: thinking perspective, methodology, and practice norms. The first is the thinking perspective. The thinking perspective of the paradigm shift in cognitive domain engineering technology is the interweaving of the three domains of "physics-information-cognition". The traditional manual paradigm, automation paradigm, and intelligent paradigm have been difficult to solve new issues in the cognitive domain. To solve the "three major problems" faced by cognitive domain technology, it is necessary to propose new theories, open up new fields, and explore new paths. The second is methodology. The methodology of the paradigm shift in cognitive domain engineering technology is multi-modal decision-making and feedback control. Through the rediscovery of relatively correct axioms, dynamic heterogeneous redundant structures and multi-agent collaborative decision-making models are established to express "known unknowns and unknown unknowns". The third is practice norms. The practice norms of the paradigm shift in cognitive domain engineering technology are to transform uncertainty problems into quantifiable problems, so as to achieve quantifiable design and verifiable measurement of safety functions of various cognitive systems.

Academician Wu Jiangxing gave a possible path to realize the paradigm shift in cognitive domain engineering technology. He described the technical blueprint for the paradigm shift in cognitive domain engineering technology from four dimensions: acquiring digital rights, building a safe and reliable social network, forming early warning capabilities to perceive "unknown risks", and establishing a cognitive immune system. At the same time, Academician Wu also pointed out that in order to promote the paradigm shift in cognitive domain engineering technology, it is also necessary to promote the paradigm shift in intelligent computing. This change requires the ability to break through the constraints of the existing "von Neumann" architecture, build a new paradigm for the development of domain-specific software and hardware collaborative computing technology that shifts from simply pursuing "general computing power" to obtaining diversified and efficient "intelligent computing power", and achieve efficient collaboration in the future "human - machine - object" virtual-real fusion environment, providing a more solid and powerful foundation for the development of cognitive domain technology.