Preface

All problems and curiosities come from lacking knowledge on the evolving reality, but what is knowledge? Is there any link between knowledge and experience? These are fundamental philosophical problems, which can be traced to Kant and Plato.

Experience starts from understanding reality. As nobody can observe reality from the view outside the world, humans have to rely on organs with limited ability to sense reality directly or through machines and then interpret reality with information processing mechanisms of minds based on the models that minds have already built. But this opinion brings a new problem: Where do the models come from? There are two possible answers: One is that our minds have innate basic models, and the other is that our minds have the ability to generalize the sensory information into some basic components of models, compose the components into larger components, and then compose the models that can interpret our observations. Our minds have the ability to zoom-in and zoom-out from different dimensions with decomposing experience into smaller components that can be interpreted by existing models or composing existing models to interpret experience.

The assumption of this component-based cognition can interpret many phenomena. Students study a subject by learning its knowledge points taught in separate courses and then linking the knowledge points to a knowledge network on the subject. Minds instruct the design of artificial systems by designing its components and then composing the components into the whole system. Computer system is constructed this way, including hardware and software systems. The fundamental principle of the component-based system concerns the least effort principle, e.g. the component-based system can be constructed and maintained with the least effort. However, the whole is usually more than the sum of components. On the other hand, a system can be constructed from different dimensions, e.g. the 3D printing systems can construct an artificial object (or system) by slicing, a different dimension of viewing components. This idea is in line with constructionism: learning is more effective when people are actively making tangible objects in reality. The above idea has a source of knowledge flow from philosophy. Kant argue that minds shape experience with common structural features.

Individuals have different knowledge structures in minds due to their differences in experience and education and have different ways to represent understandings of reality so various models are often used by different individuals to interpret the same reality. However, models built by minds are usually unable to reflect reality because human organs can only sense and experience a small space of reality even with the help of devices.

A way to approaching the evolving reality is to build human-machine-nature symbiosis to enable humans to interact with the nature more significantly, widely and sustainably through a constant reciprocal development process. To reach this

Recognition of reality concerns different methodologies based on different philosophies, including rationalism and empiricism, all play an important role in exploring reality and developing knowledge. A multi-dimensional methodology is used to analyse and solve problems and interpret solutions through this research. Coordinating different methodologies and thoughts into research process is a feature of this research.

The development of cyberspace has prominently evolved traditional view of reality into cyber-physical-social reality. Symbiosis and competition are two basic driving forces that link and co-evolve cyberspace, physical space and social space, rendering a complex cyber-physical-social space. The evolution of cyber-physical-social space emerges and develops a kind of complex intelligence — Cyber-Physical-Social Intelligence (CPSI).

Traditional research on artificial intelligence mainly focuses on developing machine intelligence while the development of CPSI is driven by fundamental interactions in and between cyberspace, physical space and social space. This research monograph investigates fundamental interactions through linking (representing reductionism) and flowing (representing non-reductionism), explores the driving forces of co-evolution, studies the principles and methods of cyber-physical-social space and carries out strategic analysis on applying the concepts, rules, principles and methods to real applications.

In the new century, human society has co-evolved with cyberspace and physical space. More and more productions and services will be developed to meet the higher level social motivation. Data flow, information flow and knowledge flow will coordinate to operate an efficient pattern of symbiosis among individuals, organizations, communities and spaces to render CPSI, which will extend human capabilities of exploring the unknown field.

This research monograph is a systematic study on CPSI for the first time. The origin of the knowledge flow can be traced to my Keynote “Future Interconnection Environment — Dream, Principle, Challenge and Practice” at WAIM 2004, which was extended to “The Future Interconnection Environment” in IEEE Computer 38(4)(2005)27-33, where an advanced infrastructure for cyber-physical-social space and the conception of ternary space were introduced. The concept of Cyber-Physical Society was introduced in my Keynote “Socio-Natural Thought Semantic Link Network: A Method of Semantic Networking in the Cyber Physical Society” at the international conference AINA 2010. The ternary space was extended to include psychological space, physiological space and mental space to form a Cyber-Physical-Physiological-Psychological-Socio-Mental Environment, where diverse spaces emerge, co-evolve, compete and cooperate with each other to extend machine intelligence and human intelligence in “Semantic Linking through Spaces for Cyber-Physical-Socio Intelligence: A Methodology” in Artificial Intelligence, 175(2011)988-1019. The thought of Cyber-Physical Society was developed in the monograph “The Knowledge Grid — Toward Cyber-Physical Society”
published by World Scientific Publishing Co. in 2012. The thought was applied to transform traditional text summarization method into a general summarization method “Multi-Dimensional Summarization in Cyber-Physical Society” published by Morgan Kaufmann in 2016.

It was the memorial date of Karl Max who contributed his lifetime to finding the fundamental socioeconomic structure and development rules of society and also the date of birth of Albert Einstein who contributed his lifetime to exploring the fundamental relations and laws of the nature when I wrote this preface. I would like to take this opportunity to salute the two great men. Integrating socioeconomic principles into research is another feature of this research.

This research monograph is to make a significant contribution to the foundation of CPSI, inspire research to explore the emerging principles on CPSI and relevant theories and methods, and provide reference framework and methods for researchers and practitioners to create new techniques that can transform the existing techniques in various applications with the evolution of cyber-physical-social space. It can be also used as an extended reading material for research-led teaching programs in universities.

The publication date was postponed from 2019 to 2020 due to the outbreak of pandemic COVID-19. During the pandemic, chapter 10 was added to reflect thinking on applying the proposed methodology to managing pandemic. Linking past and future to the present research and applications is also a feature of this research.

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