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Editor-in-Chief: **Yingxu Wang**, University of Calgary, Canada

EiC's Message: Special Issue on Advances in Cognitive Informatics (IEEE ICCI'05)

Yingxu Wang, Editor-in-Chief, University of Calgary, Canada

Abstract: The fourth issue of IJCINI is a special issue on *Advances in Cognitive Informatics (IEEE ICCI'05)* co-edited by Prof. Du Zhang and Prof. Witold Kinsner. This special issue presents a set of best articles on cognitive informatics selected from the *Proceedings of the 4th IEEE International Conference on Cognitive Informatics (ICCI'05)* held at University of California, Irvine in August 2005 (Editors: W. Kinsner, D. Zhang, Y. Wang, and J. Tsai). ICCI'05 was a successful event where MIT sent reporters to cover the entire program of the conference on the emerging transdisciplinary research field on cognitive informatics.

EDITORIAL: Special Issue on Advances in Cognitive Informatics (IEEE ICCI'05)

Du Zhang, California State University, USA

Witold Kinsner, University of Manitoba, Canada

This special issue of the *International Journal on Cognitive Informatics and Natural Intelligence (IJCiNi)* is a compendium of seven articles selected from the *Proceedings of the 2005 IEEE International Conference on Cognitive Informatics (ICCI'05)*, which was held on the campus of the University of California, Irvine, from August 8th to 10th, 2005. ICCI'05 (Kinsner, Zhang, Wang, & Tsai, 2005) was the fourth conference in this series and had its theme on natural intelligence and autonomic computing. The previous ICCI conferences include: ICCI'02 (Wang, Johnston, & Smith, 2002), ICCI'03 (Patel, Patel, & Wang, 2003), and ICCI'04 (Chan, Kinsner, & Wang, 2004). The most recent event in this series, ICCI'06, may be referred to Yao, Shi, Wang, and Kinsner (2006).

PAPER 1: On the Cognitive Processes of Human Perception with Emotions, Motivations, and Attitudes

Yingxu Wang, University of Calgary, Canada

Abstract: An interactive motivation-attitude theory is developed based on the Layered Reference Model of the Brain (LRMB) and the object-attribute-relation (OAR) model. This paper presents a rigorous model of human perceptual processes such as emotions, motivations, and attitudes. A set of mathematical models and formal cognitive processes of perception is developed. Interactions and relationships between motivation and attitude are formally described in real-time process algebra (RTPA). Applications of the mathematical models of motivations and attitudes in software engineering are demonstrated. This work is a part of the formalization of LRMB, which provides a comprehensive model for explaining the fundamental cognitive processes of the brain and their interactions. This work demonstrates that the complicated human emotional and perceptual phenomena can be rigorously modeled and formally treated based on cognitive informatics theories and denotational mathematics.

PAPER 2: A fix-Point Semantics for Rule-base Anomalies

Du Zhang, California State University, USA

Abstract: A crucial component of an intelligent system is its knowledge base (KB) that contains knowledge about a problem domain. KB development involves domain analysis, context space definition, ontological specification, and knowledge acquisition, codification, and verification. KB anomalies can affect the correctness and performance of an intelligent system. In this article, we describe a fix-point semantics for a KB that is based on a multi-valued logic. We then use the fix-point semantics to provide formal definitions for four types of KB anomalies: (1) inconsistency, (2) redundancy, (3) incompleteness, and (4) circularity. We believe such formal definitions of KB anomalies will help pave the way for a more effective KB verification process.

PAPER 3: A Unified Approach To Fractal Dimensions

Witold Kinsner, University of Manitoba, Canada

Abstract: Many scientific papers treat the diversity of fractal dimensions as mere variations on either the same theme or a single definition. There is a need for a unified approach to fractal dimensions for there are fundamental differences between their definitions. This paper presents a new description of three essential classes of fractal dimensions based on: (1) morphology, (2) entropy, and (3) transforms, all unified through the generalized-entropy-based Rényi fractal dimension spectrum. It discusses practical algorithms for computing 15 different fractal dimensions representing the classes. Although the individual dimensions have already been described in the literature, the unified approach presented in this paper is unique in terms of (1) its progressive development of the fractal dimension concept, (2) similarity in the definitions and expressions, (3) analysis of the relation between the dimensions, and (4) their taxonomy. As a result, a number of new observations have been made, and new applications discovered. Of particular interest are behavioral processes (such as dishabituation), irreversible and birth-death growth phenomena (e.g., diffusion-limited aggregates (DLAs), dielectric discharges, and cellular automata), as well as dynamical non-stationary transient processes (such as speech and transients in radio transmitters), multi-fractal optimization of image compression using learned vector quantization with Kohonen's self-organizing feature maps (SOFMs), and multi-fractal-based signal denoising.

PAPER 4: A Formal Specification of the Memorization Process

Natalia López, Universidad Complutense de Madrid, Spain
Manuel Núñez, Universidad Complutense de Madrid, Spain
Fernando L. Pelayo, Universidad de Castilla-La Mancha, Spain

Abstract: In this article we present the formal language STOchastic Process Algebra (STOPA) to specify cognitive systems. In addition to the usual characteristics of these formalisms, this language features the possibility of including stochastic time. This kind of time is useful to represent systems where the delays are not controlled by fix amounts of time, but they are given by probability distribution functions. In order to illustrate the usefulness of our formalism we will formally represent a cognitive model of the memory. Following contemporary theories of memory classification (see Solso, 1999; Squire, Knowlton, & Musen, 1993) we consider sensory buffer, short-term, and long-term memories. Moreover, borrowing from Wang and Wang (2006), we also consider the so-called action buffer memory.

PAPER 5: A Selective Sparse Coding Model with Embedded Attention Mechanism

Qingyong Li, Beijing Jiaotong University, China
Zhiping Shi, Chinese Academy of Sciences, China
Zhongzhi Shi, Chinese Academy of Sciences, China

Abstract: Sparse coding theory demonstrates that the neurons in primary visual cortex form a sparse representation of natural scenes in the viewpoint of statistics, but a typical scene contains many different patterns (corresponding to neurons in cortex) competing for neural representation because of the limited processing capacity of the visual system. We propose an attention-guided sparse coding model (AGSC). This model includes two modules: non-uniform sampling module simulating the process of retina and data-driven attention module based on the response saliency (RS). Our experiment results show that the model notably decreases the number of coefficients that may be activated and retains the main vision information at the same time. It provides a way to improve the coding efficiency for sparse coding model and to achieve good performance in both population sparseness and lifetime sparseness.

PAPER 6: the Cognitive Processes of Formal Inferences

Yingxu Wang, University of Calgary, Canada

Abstract: Theoretical research is predominately an inductive process; while applied research is mainly a deductive process. Both inference processes are based on the cognitive process and means of abstraction. This article describes the cognitive processes of formal inferences such as deduction, induction, abduction, and analogy. Conventional propositional arguments adopt static causal inference. This article introduces more rigorous and dynamic inference methodologies, which are modeled and described as a set of cognitive processes encompassing a series of basic inference steps. A set of mathematical models of formal inference methodologies is developed. Formal descriptions of the four forms of cognitive processes of inferences are presented using Real-Time Process Algebra (RTPA). The cognitive processes and mental mechanisms of inferences are systematically explored and rigorously modeled. Applications of abstraction and formal inferences in both the revilement of the fundamental mechanisms of the brain and the investigation of next generation cognitive computers are explored.

PAPER 7: Interactive Classification Using a Granule Network

Yan Zhao, University of Regina, Canada
Yiyu Yao, University of Regina, Canada

Abstract: Classification is one of the main tasks in machine learning, data mining, and pattern recognition. Compared with the extensively studied automation approaches, the interactive approaches, centered on human users, are less explored. This article studies interactive classification at three levels: At the philosophical level, the motivations and a process-based framework of interactive classification are proposed. At the technical level, a granular computing (GrC) model is suggested for re-examining not only existing classification problems but also interactive classification problems. At the application level, an interactive classification system (ICS) using a granule network as the search space, is introduced. ICS allows multi-strategies for granule tree construction and enhances the understanding and interpretation of the classification process. Interactive classification is complementary to the existing classification methods.

EVENT REPORT: toward Cognitive Informatics and Cognitive Computers: A Report on IEEE ICCI'06

Yiyu Yao, University of Regina, Canada
Zhongzhi Shi, Chinese Academy of Sciences, China
Yingxu Wang, University of Calgary, Canada
Witold Kinsner, University of Manitoba, Canada
Yixin Zhong, Beijing University of Posts and Telecommunications, China
Guoyin Wang, Chongqing University of Posts and Telecommunications, China
Zeng-Guang Hou, Chinese Academy of Sciences, China
Yuyu Yuan, Beijing University of Posts and Telecommunications, China

Abstract: The IEEE International Conference on Cognitive Informatics (ICCI) series has been established since 2002 (Chan, Kinsner, Wang, & Miller, 2004; Kinsner, Zhang, Wang, & Tsai, 2005; Patel, Patel, & Wang, 2003; Wang, Johnston, & Smith, 2002; Yao, Shi, Wang, Kinsner, 2006). The conference provides the main forum for the exchange and cross-fertilization of ideas in CI. ICCI'06 is the fifth conference of the series and was held at the Institute of Automation, Chinese Academy of Sciences, Beijing, China during July 17-19, 2006. ICCI'06 was organized by conference co-chairs Yingxu Wang (University of Calgary), Yixin Zhong (Beijing University of Posts and Telecommunications), and Witold Kinsner (University of Manitoba), and program co-chairs Zhongzhi Shi (Chinese Academy of Sciences) and Yiyu Yao (University of Regina), with the valuable support of organization co-chairs Yuyu Yuan (Beijing University of Posts and Telecommunications), Guoyin Wang (Chongqing University of Posts and Telecommunications), and Zeng-Guang Hou (Chinese Academy of Sciences, China). The program committee of ICCI'06 consists of over 50 experts in various areas of CI around the world.