Cognitive Informatics and Cognitive Computing in Year 10 and Beyond

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ABSTRACT

*Cognitive Informatics (CI) is a transdisciplinary enquiry of computer science, information sciences, cognitive science, and intelligence science that investigates into the internal information processing mechanisms and processes of the brain and natural intelligence, as well as their engineering applications in cognitive computing. The latest advances in CI leads to the establishment of cognitive computing theories and methodologies, as well as the development of Cognitive Computers (CogC) that perceive, infer, and learn. This paper reports a set of nine position statements presented in the plenary panel of IEEE ICCI*CC'11 on Cognitive Informatics in Year 10 and Beyond contributed from invited panelists who are part of the world's renowned researchers and scholars in the field of cognitive informatics and cognitive computing.*

Keywords: *Algebra, Artificial Intelligence, Cognitive Computing, Cognitive Informatics, Computational Intelligence, Denotational Mathematics, Industrial Applications, Natural Intelligence, Visual Semantic Algebra*

1. INTRODUCTION

The theories of informatics and their perceptions on the object of information have evolved from the classic information theory, modern informatics, to cognitive informatics in the last six de-

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cades. The *classic information theories* (Shannon & Weaver, 1949; Bell, 1953; Goldman, 1953), particularly Shannon's information theory (Shannon, 1948), are the first-generation informatics, which study signals and channel behaviors based on statistics and probability theory. The *modern informatics* studies information as properties or attributes of the natural world that can be distinctly elicited, generally abstracted, quantitatively represented, and mentally processed (Wang, 2002a, 2003a, 2003b). The first- and second-generation informatics put emphases on external information processing, which are yet to be extended to observe the fundamental fact that human brains are the original sources and final destinations of information. Any information must be cognized by human beings before it is understood, comprehended, and consumed.

The aforementioned observations have led to the establishment of the third-generation informatics, *cognitive informatics* (CI), a term coined by Wang in a keynote in 2002 (Wang, 2002a). CI is defined as the science of cognitive information that investigates into the internal information processing mechanisms and processes of the brain and natural intelligence, and their engineering applications via an interdisciplinary approach. It is recognized in CI that *information* is the third essence of the natural world supplementing to matter and energy. *Informatics* is the science of information that studies the nature of information, its processing, and ways of transformation between information, matter and energy.

The IEEE series of *International Conferences on Cognitive Informatics and Cognitive Computing* (ICCI*CC) has been established since 2002 (Wang, 2002a; Wang et al., 2002). The inaugural ICCI event in 2002 was held at University of Calgary, Canada (ICCI'02) (Wang et al., 2002), followed by the events in London, UK (ICCI'03) (Patel et al., 2003); Victoria, Canada (ICCI'04) (Chan et al., 2004); Irvine, USA (ICCI'05) (Kinsner et al., 2005); Beijing, China (ICCI'06) (Yao et al., 2006); Lake Tahoe, USA (ICCI'07) (Zhang et al., 2007); Stanford University, USA (ICCI'08) (Wang et al., 2008); Hong Kong (ICCI'09) (Baciu et al., 2009); Tsinghua University, Beijing (ICCI'10) (Sun et al., 2010); and Banff, Canada (ICCI*CC'11) (Wang et al., 2011). Since its inception, the ICCI*CC series has been growing steadily in its size, scope, and depth. It attracts worldwide researchers from academia, government agencies, and industry practitioners. The conference series provides a main forum for the exchange and cross-fertilization of ideas in the new research field of CI toward revealing the cognitive mechanisms and processes of human information processing and the approaches to mimic them in cognitive computing.

A series of fundamental breakthroughs have been recognized and a wide range of applications has been developed in cognitive informatics and cognitive computing in the last decade. The representative paradigms and technologies developed in cognitive informatics are such as cognitive computing, cognitive computers, abstract intelligence, formal knowledge representation, cognitive learning engines, denotational mathematics for cognitive system modeling, and applicants in cognitive systems.

This paper is a summary of the position statements of panellists presented in the *Plenary Panel on Cognitive Informatics in Year 10 and Beyond* in IEEE ICCI*CC 2011 held in Banff, Alberta, Canada during August 18-20, 2011 (Wang et al., 2011). It is noteworthy that the individual statements and opinions included in this paper may not necessarily be shared by all panellists.

2. THE FRAMEWORK OF COGNITIVE INFORMATICS AND COGNITIVE COMPUTING

The framework of cognitive informatics (Wang, 2003a, 2007b) and cognitive computing (Wang, 2006, 2009b, 2010a; Wang, Zhang, & Kinsner, 2010) can be described by the following theories, mathematical means, cognitive models, computational intelligence technologies, and applications.