Perspectives on eBrain and Cognitive Computing

Yingxu Wang, Department of Electrical Engineering and Computer Engineering, University of Calgary, Calgary, AB, Canada

James A. Anderson, Department of Cognitive, Linguistic and Psychological Sciences, Brown University, Providence, RI, USA

George Baciu, Department of Computing, Hong Kong Polytechnic University, Hong Kong, Hong Kong

Gerhard Budin, Center for Translation Studies, Vienna University, Vienna, Austria

D. Frank Hsu, Department of Computer & Information Sciences, Fordham University, New York, NY, USA

Mitsuru Ishizuka, Department of Creative Informatics & Department of Information and Communication Engineering, Graduate School of Information Science and Technology, University of Tokyo, Tokyo, Japan

Witold Kinsner, Department of Electrical & Computer Engineering, University of Manitoba, Winnipeg, MB, Canada

Fumio Mizoguchi, Tokyo University of Science, Tokyo, Japan

Toyoaki Nishida, Department of Intelligence Science and Technology, Graduate School of Informatics, Kyoto University, Kyoto, Japan

Kenji Sugawara, Department of Information and Network Science, Faculty of Computer and Network Science, Chiba Institute of Technology, Narashino, Chiba, Japan

Shusaku Tsumoto, Department of Medical Informatics, Faculty of Medicine, Shimane University, Izumo City, Japan

Du Zhang, Department of Computer Science, College of Engineering and Computer Science, California State University-Sacramento, Sacramento, CA, USA

ABSTRACT

*Cognitive Informatics (CI) is a discipline spanning across computer science, information science, cognitive science, brain science, intelligence science, knowledge science, and cognitive linguistics. CI aims to investigate the internal information processing mechanisms and processes of the brain, the underlying abstract intelligence theories and denotational mathematics, and their engineering applications in cognitive computing and computational intelligence. This paper reports a set of nine position statements presented in the plenary panel of IEEE ICCI*CC'12 on eBrain and Cognitive Computers 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: *Abstract Intelligence, Artificial Intelligence, Cognitive Informatics, Computational Intelligence, Denotational Mathematics, eBrain, Industrial Applications, Natural Intelligence*

DOI: 10.4018/jcini.2012100101

1. INTRODUCTION

Cognitive Informatics (CI) is a transdisciplinary enquiry of computer science, information science, 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 (Wang, 2002a, 2003, 2006, 2007b, 2007c, 2007d, 2009a, 2009b, 2012c, 2012d, 2012f; Wang & Kinsner, 2006; Wang & Wang, 2006; Wang, Kinsner, & Zhang, 2009; Wang & Berwick, 2012; Wang, Kinsner, et al., 2009; Wang et al., 2010; Wang, Widrow, et al., 2011).

Fundamental theories developed in CI cover the *Matter-Energy-Information-Intelligence* (MEII) model (Wang, 2007a, 2007b), the *Layered Reference Model of the Brain* (LRMB) (Wang et al., 2006), the *Object-Attribute-Relation* (OAR) model of internal information representation in the brain (Wang, 2007c), the *Cognitive Functional Model of the Brain* (CFMB) (Wang & Wang, 2006), the *Abstract Intelligence Model of the Brain* (AIMB), *Natural Intelligence* (Wang, 2007b), *Abstract Intelligence* (Wang, 2009a, 2012c), *Neuroinformatics* (Wang, 2007b; Wang & Fariello, 2012), *Denotational Mathematics* (Wang, 2002b, 2007a, 2008a, 2008b, 2008c, 2008d, 2009d, 2011a, 2011b, 2012a, 2012b, 2012e, 2012g, 2013), *Cognitive Linguistics* (Wang & Berwick, 2012; Wang, Berwick, & Luo, 2012b), *Formal Neural Signal and Circuit Theories* (Wang & Fariello, 2012), *Cognitive Systems* (Kinsner, 2011; Wang, 2010b, 2011c). Recent studies on LRMB in cognitive informatics reveal an entire set of cognitive functions of the brain and their cognitive process models, which explain the functional mechanisms and cognitive processes of the natural intelligence with 47 cognitive processes at seven layers known as the sensation, action, memory, perception, meta-cognitive, inference, and advanced cognitive layers (Wang et al., 2006).

Cognitive Computing (CC) is a novel paradigm of intelligent computing methodologies and systems based on CI that implements computational intelligence by autonomous inferences and perceptions mimicking the mechanisms of the brain (Wang, 2006, 2009b, 2009c, 2010a, 2012b; Wang, Berwick, et al., 2011). CC is emerged and developed based on the multidisciplinary research in CI, abstract intelligence, and denotational mathematics (Wang, 2009a, 2012c).

The latest advances in CI and CC, as well as denotational mathematics, enable a systematic solution for the future generation of intelligent computers known as *cognitive computers* (CogCs) that think, perceive, inference, and learn (Wang, 2006, 2009b, 2010a, 2012b, 2012h). A CogC is an intelligent computer for knowledge processing as that of a conventional von Neumann computer for data processing. CogCs are designed to embody *machinable intelligence* such as computational inferences, causal analyses, knowledge manipulation, machine learning, and autonomous problem solving. Recent studies in cognitive computing reveal that the computing power in computational intelligence can be classified at four levels: *data, information, knowledge,* and *intelligence* from the bottom up. Traditional von Neumann computers are designed for imperative data and information processing by stored-program-controlled mechanisms. However, the increasing demand for advanced computing technologies for knowledge and intelligence processing in the high-tech industry and everyday lives require novel cognitive computers for providing autonomous computing power for various cognitive systems mimicking the natural intelligence of the brain.

eBrain is an abstract brain system that models the structures of human brain and embodies the functions of human brain at the logic (abstract intelligence), cognitive, physiological, and neurological levels. eBrain can be implemented and simulated by CogCs on the basis of the LRMB, CFMB, and AIMB models.

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).