Chapter 1.4
The Theoretical Framework of Cognitive Informatics

Yingxu Wang
University of Calgary, Canada

ABSTRACT

Cognitive Informatics (CI) is a transdisciplinary enquiry of the internal information processing mechanisms and processes of the brain and natural intelligence shared by almost all science and engineering disciplines. This article presents an intensive review of the new field of CI. The structure of the theoretical framework of CI is described encompassing the Layered Reference Model of the Brain (LRMB), the OAR model of information representation, Natural Intelligence (NI) vs. Artificial Intelligence (AI), Autonomic Computing (AC) vs. imperative computing, CI laws of software, the mechanism of human perception processes, the cognitive processes of formal inferences, and the formal knowledge system. Three types of new structures of mathematics, Concept Algebra (CA), Real-Time Process Algebra (RTPA), and System Algebra (SA), are created to enable rigorous treatment of cognitive processes of the brain as well as knowledge representation and manipulation in a formal and coherent framework. A wide range of applications of CI in cognitive psychology, computing, knowledge engineering, and software engineering has been identified and discussed.

INTRODUCTION

The development of classical and contemporary informatics, the cross fertilization between computer science, systems science, cybernetics, computer/software engineering, cognitive science, knowledge engineering, and neuropsychology, has led to an entire range of an extremely interesting and new research field known as Cognitive Informatics (Wang, 2002a, 2003a, b, 2006b; Wang, Johnston & Smith 2002; Wang & Kinsner, 2006). *Informatics* is the science of information that studies the nature of information; it's processing, and ways of transformation between information, matter, and energy.

Definition 1. *Cognitive Informatics* (CI) is a transdisciplinary enquiry of cognitive and information sciences that investigates the internal in-

formation processing mechanisms and processes of the brain and natural intelligence, and their engineering applications via an interdisciplinary approach.

In many disciplines of human knowledge, almost all of the hard problems yet to be solved share a common root in the understanding of the mechanisms of natural intelligence and the cognitive processes of the brain. Therefore, CI is a discipline that forges links between a number of natural science and life science disciplines with informatics and computing science.

The structure of the theoretical framework of CI is described in Figure 1, which covers the Information-Matter-Energy (IME) model (Wang, 2003b), the Layered Reference Model of the Brain (LRMB) (Wang, Wang, Patel & Patel, 2006), the Object-Attribute-Relation (OAR) model of information representation in the brain (Wang, 2006h; Wang & Wang, 2006), the cognitive informatics model of the brain (Wang, Liu, & Wang, 2003; Wang & Wang, 2006), Natural Intelligence (NI) (Wang, 2003b), Autonomic Computing (AC) (Wang, 2004), Neural Informatics (NeI) (Wang, 2002a, 2003b, 2006b), CI laws of software (Wang, 2006f), the mechanisms of human perception processes (Wang, 2005a), the cognitive processes of formal inferences (Wang, 2005c), and the formal knowledge system (Wang, 2006g).

In this article, the theoretical framework of CI is explained in the fundamental theories of CI section. Three structures of new descriptive

Figure 1. The theoretical framework of CI