Abstract Intelligence:
Embodying and Enabling Cognitive Systems by Mathematical Engineering

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ABSTRACT

Basic studies in denotational mathematics and mathematical engineering have led to the theory of abstract intelligence (ai), which is a set of mathematical models of natural and computational intelligence in cognitive informatics (CI) and cognitive computing (CC). Abstract intelligence triggers the recent breakthroughs in cognitive systems such as cognitive computers, cognitive robots, cognitive neural networks, and cognitive learning. This paper reports a set of position statements presented in the plenary panel (Part II) of IEEE ICII*CC'16 on Cognitive Informatics and Cognitive Computing at Stanford University. The summary is contributed by invited panelists who are part of the world’s renowned scholars in the transdisciplinary field of CI and CC.

KEYWORDS

Abstract Intelligence, Applications, Artificial Intelligence, Brain-Inspired Systems, Cognitive Computers, Cognitive Engineering, Cognitive Informatics, Cognitive Robotics, Cognitive Systems, Computational Intelligence, Denotational Mathematics, Mathematical Engineering

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1. INTRODUCTION

Cognitive Informatics (CI) is a transdisciplinary enquiry of the internal information processing mechanisms and processes of the brain and abstract intelligence, as well as their applications in cognitive computing and cognitive engineering (Wang, 2002, 2003, 2006, 2007a; Wang et al., 2002, 2009b, 2010). CI is a contemporary field spanning across computer science, information science, cognitive science, brain science, neuroscience, intelligence science, knowledge science, robotics, cognitive linguistics, cognitive philosophy, and cognitive engineering. Cognitive Computing (CC) is a novel paradigm of intelligent computing platforms of cognitive methodologies and systems based on CI, which embodying computational intelligence by cognitive and autonomous systems mimicking the mechanisms of the brain (Wang, 2011b, 2012e, 2015b, 2016a; Wang et al., 2006). IEEE ICCI*CC’16 on Cognitive Informatics and Cognitive Computing has been held at Stanford University during Aug. 22-23, 2016. The theme of ICCI*CC’16 was on cognitive computing, big data cognition, and machine learning (Widrow, 2016; Zadeh, 2016; Wang et al., 2016b).

CI and CC emerged from transdisciplinary studies in both natural intelligence in cognitive/brain sciences (Anderson, 1983; Sternberg, 1998; Reisberg, 2001; Wilson & Keil, 2001; Wang, 2002, 2007a; Wang et al., 2002, 2008, 2009, 2016) and artificial intelligence in computer science (Bender, 1996; Poole et al., 1997; Zadeh, 1999; Widrow et al., 2015; Wang, 2010a, 2016c). Towards formal explanation of the structures and functions of the brain, as well as their intricate relations and interactions, formal models are sought for revealing the principles and mechanisms of the brain. This leads to the theory of abstract intelligence ($\alpha$I) that investigates into the brain via not only inductive syntheses of theories and principles of intelligence science through mathematical engineering, but also deductive analyses of architectural and behavioral instances of natural and artificial intelligent systems through cognitive engineering. The key methodology suitable for dealing with the nature of $\alpha$I is mathematical engineering (ME), which is an emerging discipline of contemporary engineering that studies the formal structural models and functions of complex abstract and mental objects and their systematic and rigorous manipulations (Wang, 2015a).

This paper is a summary of the position statements of invited panellists presented in the Plenary Panel on Perspectives on Cognitive Computing, Big Data Cognition, and Machine Learning (Part II), which was held in IEEE ICCI*CC 2016 (Wang et al., 2016b/c) at Stanford University, USA, on Aug. 23, 2016. It is noteworthy that the individual statements and opinions included in this paper may not necessarily be shared by all panellists.

2. THE THEORETICAL FRAMEWORK OF BRAIN AND INTELLIGENCE SCIENCES

The theoretical framework of brain science and intelligence science can be described as shown in Figure 1 according to CI studies (Wang, 2007a, 2008, 2009a, 2011b, 2012c/e, 2015b/d, 2016a). It it recognized that the brain may be explained by a hierarchically reductive structure at the logical, cognitive, physiological, and neurological levels from the bottom up, which form the studies known as abstract intelligence, cognitive informatics, brain informatics, and neuroinformatics. The synergy of multidisciplinary studies at all levels leads to the theory of CI for explaining the brain. The fundamental theories underpinning the framework of brain and intelligence sciences are abstract intelligence (Wang, 2009a, 2012c, 2015a) and denotational mathematics (Wang, 2008, 2009c, 2012a/b/d, 2015a).

- Neuroinformatics (NI): NI is the fundamental level of brain studies in the hierarchical framework of brain/intelligence science, which studies primitive forms and mechanisms of the natural intelligence at the neurological level towards those of brain informatics at the physiological level, cognitive informatics at the functional level, and abstract intelligence at the logical level (Wang, 2007c, 2013a; Wang and Fariello, 2012).
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