Perspectives on Cognitive Computing and Applications

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ABSTRACT

Cognitive Computing (CC) is an emerging paradigm of intelligent computing theories and technologies based on cognitive informatics, which implements computational intelligence by autonomous inferences and perceptions mimicking the mechanisms of the brain. The development of Cognitive Computers (cC) is centric in cognitive computing methodologies. A cC is an intelligent computer for knowledge processing as that of a conventional von Neumann computer for data processing. This paper summarizes the presentations of a set of 6 position papers presented in the ICCI'10 Plenary Panel on Cognitive Computing and Applications 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: *Artificial Intelligence, Cognitive Computing, Denotational Mathematics, eBrain, Engineering Applications, Granular Algebra, Machinable Intelligence*

INTRODUCTION

A wide range of international efforts has been focused on the studies of the new generation of intelligent computers known as cognitive computers, which also known as intelligent computers, brain-like computers, artificial brains, and human centric computers in related research. A *Cognitive Computer* (cC) is an intelligent computer for knowledge processing as that of a conventional von Neumann computer for data processing.

The development of cC is centric in cognitive computing research. *Cognitive Computing* (CC) is an emerging paradigm of intelligent computing methodologies and systems based on cognitive informatics that implements computational intelligence by autonomous inferences and perceptions mimicking the mechanisms of the brain (Wang, 2002, 2003, 2006, 2007a, 2007b, 2009a, 2009b,2010a, 2010b, 2010c,

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2010d; Wang & Wang, 2006; Wang & Kinsner, 2006; Wang et al., 2006, 2009a). CC has been emerged and developed based on the multi-disciplinary research in cognitive informatics (Wang, 2002, 2003, 2007b, 2007c; Wang et al., 2009a, 2009c), which 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.

This paper is a summary of the position statements of panellists presented in the *Plenary Panel on Cognitive Computing and Applications* in IEEE ICCI 2010 at Tsinghua University held in July 2010 (Sun et al., 2010). It is noteworthy that the individual statements and opinions included in this paper may not necessarily be shared by all panellists.

COGNITIVE COMPUTING: THEORIES AND APPLICATIONS

The latest advances in cognitive informatics, abstract intelligence, and denotational mathematics have led to a systematic solution for the future generation of intelligent computers known as *cognitive computers* (cCs) that think, perceive, learn, and reason (Wang, 2006, 2009a, 2009b). A cC is an intelligent computer for knowledge processing as that of a conventional von Neumann computer for data processing. cCs are designed to embody *machinable intelligence* such as computational inferences, causal analyses, knowledge manipulation, learning, and problem solving.

The term *computing* in a narrow sense is an application of computers to solve a given problem by imperative instructions; while in a broad sense, it is a process to implement the instructive intelligence by a system that transfers a set of given information or instructions into expected intelligent behaviors.

The *essences* of computing are both its *data objects* and their predefined computational *operations*. From these facets, different computing paradigms may be comparatively analyzed as follows:

(a) Conventional computing
   - *Data objects*: abstract bits and structured data
   - *Operations*: logic, arithmetic, and functions

(b) Cognitive computing (CC)
   - *Data objects*: words, concepts, syntax, and semantics
   - *Basic operations*: syntactic analyses and semantic analyses
   - *Advanced operations*: concept formulation, knowledge representation, comprehension, learning, inferences, and causal analyses

The above analyses indicate that cC is an important extension of conventional computing in both data objects modeling capabilities and their advanced operations at the abstract level of concept beyond bits. Therefore, cC is an intelligent knowledge processor that is much closer to the capability of human brains thinking at the level of concepts rather than bits. It is recognized that the basic unit of human knowledge in natural language representation is a concept rather than a word (Wang, 2008b, 2010e), because the former conveys the structured semantics of a word with its intention (attributes), extension (objects), and relations to other concepts in the context of a knowledge network.

It is noteworthy that, although the semantics of words may be ambiguity, the semantics of concept is always unique and precise in CC. For example, the word, "bank", is ambiguity because it may be a notion of a financial institution, a geographic location of raised ground of a river/lake, and/or a storage of something. However, the three individual concepts derived from bank, i.e., b_o = bank(organization), b_r = bank(river), and b_s = bank(storage), are precisely unique, which can be formally described in concept algebra [Wang, 2008b] for CC as shown in Fig. 1. In the examples of concepts, a generic framework of a concept is represented