Formal Descriptions of Cognitive Processes of Perceptions on Spatiality, Time, and Motion

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ABSTRACT

Recent researches in both cognitive informatics and computational intelligence are interested in the human perceptual senses of spatiality, time, and motion, which are fundamental cognitive life functions according to the Layered Reference Model of the Brain (LRMB). This paper presents the cognitive process of human perceptual senses on spatiality, time, and motion. The sense of spatiality is investigated into the coordinate system, orientations, and cognitive maps, followed by the development of the mathematical model and the cognitive process of human spatial senses. The sense of time with the biological clocks, cognitive clocks, and their mathematical models are analyzed in order to explain the cognitive process of human time sense. On the basis of the formal models of senses of spatiality and time, the sense of motion is modeled as a complex sense incorporating both of spatiality and time. Then, the cognitive, mathematical, and process models of the sense of motion are rigorously established. This work provides a theoretical framework for the rigorous implementation of the intelligent behaviors of cognitive computers, autonomous agent systems, and robots in cognitive informatics and computational intelligence. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: *AI; The Brain; Cognitive Informatics; Computational Intelligence; Denotational Mathematics; External Senses; LRMB; Mathematical Models; Perceptual Senses; RTPA; Sense of Motion; Sense of Spatiality; Sense of Time; Space-Time*

INTRODUCTION

The human perceptual sense of spatiality, time, and motion are fundamental subjects studied in cognitive informatics, physics, cognitive psychology, and computational intelligence (Smith, 1993; Gray, 1994; Pinel, 1997; Matlin, 1998; Westen, 1999; Reisberg, 2001; Wilson and Keil, 1999; Wang and Wang, 2006, 2008; Wang et al., 2006). Cognitive informatics (Wang, 2002a, 2003, 2007b) is an emerging discipline that studies the internal information processing mechanisms and processes of the

natural intelligence - human brains and minds. In cognitive informatics, the human perceptual senses of spatiality, time, and motion are fundamental cognitive life functions according to the Layered Reference Model of the Brain (LRMB) (Wang et al., 2006), which reveals that the brain is functioning with 39 fundamental cognitive processes at 7 layers known as the *sensation*, *memory*, *perception*, *action*, *meta-cognitive*, *meta-inference*, and *higher cognitive* layers from the bottom-up.

The cognitive functions of the perception layer of LRMB may be considered as the thinking engine of the brain with a 7-layer hierarchical structure, known as the seven *basic perceptual senses*, supplementary to the five *external sensations* of vision, auditory, smell, tactility, and tastes, which implements self consciousness inside the abstract memories of the brain (Smith, 1993; Pinel, 1997; Matlin, 1998; Westen, 1999; Reisberg, 2001; Wang et al., 2006).

Definition 1. *The perception layer is a subconscious layer of life functions of the brain for maintaining conscious life functions and browsing internal abstract memories in the cognitive models of the brain.*

Figure 1. The hierarchical model of human perceptual senses
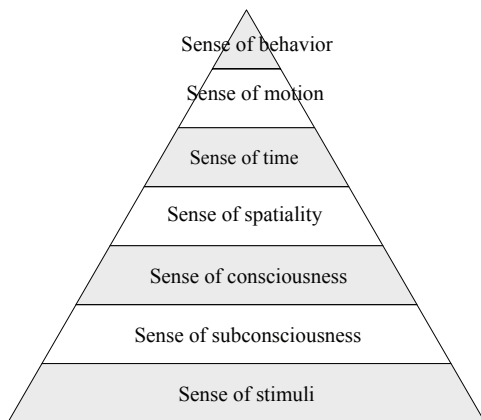
The perception layer of LRMB is a part of the subconscious life functions. The perception layer is the internal sensory layer that encompasses consciousness, stimuli, emotions, motivations, attitudes, sense of behaviors, sense of spatiality, sense of time, and sense of motion. This article puts emphases on the senses of spatiality, time, and motion, while the other perceptual processes at the perception layer of LRMB may be referred to (Wang, 2007c; Wang and Wang, 2008).

The entire human perceptual senses can be described in the 7-layer hierarchical model as shown in Figure 1, where the 7-layers perceptional senses are: L1 – stimuli; L2 – subconsciousness; L3 – consciousness; L4 – spatiality; L5 – time; L6 – motion; and L7 - behaviors from the bottom-up.

This article formally presents the cognitive process of perceptions on spatiality, time, and motion. The human senses of spatiality such as the coordinate system, orientations, and cognitive maps are investigated, which leads to the establishment of the mathematical model and the cognitive process of human spatial sense. Then, the sense of time from the aspects of biological clocks, cognitive clocks, and their mathematical models are analyzed in order to explain the cognitive process of time. Based on the formal models developed in the preceding sections, the senses of space and time, the sense of motion as a complex sense incorporating both of spatiality and time is elaborated with a set of cognitive, mathematical, and process models.

THE SENSE OF SPATIALITY

The sense of spatiality is not only studied in physics, but also interested in cognitive informatics, psychology, and computational intelligence.

Definition 2. *The sense of spatiality is the most fundamental awareness and perception of the surrounding environment of a person, which encompasses the coordinate system, orientations, and cognitive maps.*

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