Chapter III

Modeling Field Theory of Higher Cognitive Functions

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Abstract

The chapter discusses a mathematical theory of higher cognitive functions, including concepts, emotions, instincts, understanding, imagination and intuition. Mechanisms of the knowledge instinct are proposed, driving our understanding of the world. Aesthetic emotions and perception of beauty are related to “everyday” functioning of the mind. We briefly discuss neurobiological grounds as well as difficulties encountered by previous attempts at mathematical modeling of the mind encountered since the 1950s. The mathematical descriptions below are complemented with detailed conceptual discussions so the content of the chapter can be understood without necessarily following mathematical details. We relate mathematical results and computational examples to cognitive and philosophical discussions of the mind. Relating a mathematical theory to psychology, neurobiology and philosophy will improve our understanding of how the mind works.
Working of the Mind

How the mind works has been a subject of discussions for millennia; from Ancient Greek philosophers to mathematicians, to modern cognitive scientists. Words like mind, thought, imagination, emotion and concept present a challenge: People use these words in many ways colloquially, but in cognitive science and in mathematics of intelligence they have not been uniquely defined and their meaning is a subject of active research and ongoing debates (for the discussions and further references see: Grossberg (1988); Albus, and Meystel (2001); Perlovsky (2001). Standardized definitions come after completion of a theoretical development (for instance “force” was defined by Newton’s laws, following centuries of less precise usage). Whereas the mind theory is a developing science, this chapter adheres to the following guidelines regarding our proposals: (1) they must correspond to current discussions in the scientific and mathematical community, (2) they must correspond to philosophical discussions and general cultural usage, (3) they must be clear and mathematically tractable, and finally (4) deviations or discrepancies must be noted and discussed. A dictionary definition of the mind, which we take as a starting point, includes conscious and unconscious processes, thought, perception, emotion, will, memory and imagination, and it originates in brain (The American Heritage College Dictionary, 2000). These constituent notions will be discussed throughout the chapter. Specific neural mechanisms in the brain “implementing” various mind functions constitute the relationship between the mind and brain. We will discuss possible relationships of the proposed mathematical descriptions to neural structures in the brain.

The problem addressed in this chapter is developing a mathematical technique suitable to describe higher cognitive functions. Such a technique could serve two purposes. First, it would lead to the development of smart computers and intelligent robots. Second, it would help to unify and clarify complex issues in philosophy, psychology, neurobiology and cognitive science. I rely on an underlying methodological assumption that “the minds” are actually existing physical entities, and in various disciplines I am interested in contents related to this assumption of “physics of the mind.” Achieving the two purposes of intelligent computers and mind theory will require the collaboration of many people. Developing intelligent computers based partially on ideas described in this chapter is being pursued by several dozens of companies. Similarly, several university groups pursue research relating these ideas to specific disciplines (philosophy, psychology, neurobiology, evolution of languages, psycholinguistics and even musical theory). In this chapter the purpose is limited to describing the mathematical technique and to making a step toward relating it to a vast field of philosophy, psychology, neurobiology and cognitive science. Needless to say, not every point of view can be addressed, and not every reader can be satisfied. The aim of the chapter will be achieved if the reader gets a taste for and an interest in the unifying approach to this vast and fascinating field.

A broad range of opinions exists about the mathematical methods suitable for the description of the mind. Founders of artificial intelligence, including Allan Newell (1983) and Marvin Minsky (1988), thought that formal logic was sufficient and no specific mathematical techniques would be needed to describe the mind. An opposite view was advocated by Brian Josephson (1997) and Roger Penrose (1994), suggesting that the
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