Chapter 2
Topological Semiotic Knowledge Representation

ABSTRACT

This chapter describes cognitive models that organize implicit symbols into meaningful relational network structures. With an understanding of implicit symbols, there is evidence that informational processes on the cortical level can create and maintain multileveled hierarchically nested graphs and diagram – like structures. This topological model reflects hierarchically ordered knowledge of world structure and processes. Suggested models reflect systems, and they have structural relations embedded in the model. Ability to generate on fly new meaningful graphs and diagrams allows for modeling phenomena of intelligence like analogies, conceptual blending, and many others.

INTRODUCTION

Hebbian learning is studied pretty well, possibly due to its mechanism based on the adaptive statistics. Much less attention was paid in the past to other mechanisms such as for instance Pavlovian reflex (1927), which links neural assemblies that were activated simultaneously or sequentially.

In April 1903, Pavlov presented his early work on the conditioned reflex to the International Congress of Medicine, Madrid. In his book "Natural Science and the Brain," he proposed that the conditioned reflex developed through the action of two types of brain process. The first of these was a "temporary

DOI: 10.4018/978-1-5225-2431-1.ch002

union, i.e., the establishment of a new connection in the conducting paths". In 1909, Pavlov proposed a theory of associative learning.

Briefly, the brain can establish associations between separate areas that were activated either simultaneously, or within a short period. If this is a stable pattern, it will be repeated. And this is a great chance that such a repeated pattern will be observed in future with a high degree of certainty.

Conditional reflex demonstrates the human capability to capture the connection between cause and effect. Pavlov showed that even very artificial sequence of events might create such a link.

There is some misconception on how this mechanism works and how this connection can be established, at least on the modeling level. Some models assume that this remote link may be set after activation repeats. But such a model can work only for local links. For remote links, a fast connection between the remote areas must be established from the very beginning. Then it can be either kept or disappear if this activation was random and not repeated regularly.

Such links form relational structures, and from the informational standpoint, such a structure looks like a graph or a diagram.

I. Pavlov (1927) discovered reflex as a learning mechanism, and D. Hebb (1949) discovered how such learning happens. The mainstream of research was focused mainly on the models of Hebbian learning. But learning is just one of the many processes in the brain, and such learning models just don't seem to capture the essence of biological systems. There is always something organic missing, like, for instance, attention – a top-down control process. The list can be continued.

Vector space or symbolic space is not enough for the explanation of informational processes related to the image understanding. Understanding cannot be reduced to recognition, the same way as intelligence cannot be reduced to memory recall. It requires such a computational mechanism that not only learns but also works with the dynamic spatial relationships and structures, actually allowing fast creation of new dynamic structures.

An implicit symbol is an equivalent to a recognized feature, or a structural combination of features, or an object. In a more general sense, such symbol denotes a pattern. The pattern is a structure, repeated in time, or space. Therefore, in the Network-Symbolic systems, a feature or an object can be identical to the node of such system, where such node can also represent a symbol, or a predicate, or a pattern, or a lower-level structure.