In his book “Conceptual Spaces - The Geometry of Thought”, Peter Gärdenfors [1] presents a pioneering theory for representing conceptual knowledge, the basic construct of human thinking and reasoning [4]. The conceptual level is not seen as an alternative to traditional approaches of knowledge representation in artificial intelligence, namely symbolic or subsymbolic methods. Instead, it is meant to complement both approaches. The book is highly commendable and worth reading, as it does not only tackle many fundamental problems of knowledge representation such as grounding [3], concept formation and similarity comparisons [2], but also outlines novel and enlightening ideas how to overcome these.

The book introduces the notion of a conceptual space as a framework for representing knowledge at the conceptual level. It is motivated by contrasting it to other levels of knowledge representation: The highest level, the symbolic level, conceptualizes the human brain as a computing device. Knowledge is represented based on a language consisting of a set of symbols. Logical operations can be performed on these symbols to infer new knowledge. Human reasoning is modeled as a symbol manipulation process. Classical, symbolic artificial intelligence does not very well support central cognitive processes such as the acquisition or formation of new concepts and similarity comparisons. The lowest level, the subsymbolic knowledge representation, is oriented towards the neuro-biological structure of the human brain. Concepts are implicitly represented via activation patterns within the neural network. Learning is modeled by modifying the activation of neurons. Explicit representation of knowledge and concepts is not possible.

At the intersection between the symbolic and the subsymbolic level, Gärdenfors introduces the conceptual level. The theory of conceptual spaces is based on semantic spaces with a geometric structure: A conceptual space is formed by a set of quality dimensions. One or several quality dimensions model one domain. An important example used throughout the book is the color domain represented by the quality dimensions hue, saturation and brightness. Conceptual spaces have a cognitive foundation because domains can be grounded in qualities perceivable by the human sensory apparatus. Concepts are represented as conceptual regions described by their properties on the quality dimensions. The geometric structure of conceptual spaces makes it possible to determine distances and therefore provides an inherent similarity measure by taking the distance in the conceptual space as indicator of the semantic similarity. The notion of similarity is an important construct for modeling categorization and concept formation. Using similarity for reasoning can also reflect well the vagueness typical for human reasoning.

The strong focus on the cognitive foundation makes the book particularly valuable. It contains many challenging claims which are related to various disciplines by giving evidence from a wide range of literature. This shows the huge and highly interdisciplinary background of the author. Unfortunately, Gärdenfors describes his theory only at a very abstract level and for-bears from describing algorithms for the formalization of his theory. The realization of a computational model for conceptual spaces bears many practical problems which still have to be solved. Moreover, no empirical evidence is given for his pioneering, sometimes revolutionary ideas. However, these shortcomings should be considered as challenges to solve in the future.

The target audience of the book is highly interdisciplinary: since Gärdenfors tackles the problem of cognitive knowledge representation from a psychologic and computer science perspective as well as from a philosophic, neuroscience and linguistic point of view, this book is worth reading for researchers from many different areas. It is required reading for researchers in cognitive science or artificial intelligence interested in knowledge representation. The book has a clear structure and is very well written. The convincing examples throughout the book illustrate the findings very well and make it easy to understand. Therefore I would also deem Gärdenfors’ book to be suitable for students as introducing literature to various problem fields in cognitive science. It gives readers from related areas the chance to look beyond one’s own nose and get to know an interdisciplinary way of thinking. The book certainly meets the expectations of the highly interdisciplinary research area cognitive science.

References

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