Towards concept formation in conceptual spaces

Lucas Bechberger[1,*], Kai-Uwe Kühnberger[1]

[1]Institute of Cognitive Science, Osnabrück University, Wachsbleiche 27, 49090 Osnabrück, Germany
*Corresponding author: lucas.bechberger@uni-osnabrueck.de

One common criticism of symbolic AI approaches is that the symbols on which these approaches operate do not contain any meaning: for the system, they are just arbitrary tokens that can be manipulated in some way. These tokens can only receive meaning though their interpretation by a human. This lack of inherent meaning in abstract symbols is described as the "symbol grounding problem" [1]. One way of trying to solve this problem is to devise a grounding mechanism that connects abstract symbols to the real world, e.g., to perception.

The framework of conceptual spaces [2] is such an approach. It attempts to bridge the gap between symbolic and subsymbolic AI by proposing an intermediate layer of representation. This conceptual layer resides between the symbolic and the subsymbolic layer and provides geometric means to connect them to each other.

A conceptual space is a high-dimensional space spanned by a number of quality dimensions (e.g., temperature, time, hue, pitch) that are based on perception and/or subsymbolic processing. The framework of conceptual spaces proposes that regions in this space correspond to concepts (like "apple" or "red"), i.e., to the meaning of abstract symbols. Abstract symbols can thus be grounded in reality by linking them to regions in a conceptual space whose dimensions in turn are based on perception.

One important question that is left unaddressed by the conceptual spaces framework is concerned with concept formation: How can these geometrical representations of concepts come into existence?

In this poster, we will present an outline of the first author's PhD research, addressing exactly this question: How can an artificial agent learn about meaningful regions in the conceptual space purely from perceptual data?

Our approach towards solving this problem is to devise an online clustering algorithm that groups a stream of observations (represented as points in the conceptual space) into meaningful clusters. These clusters will be fuzzy in nature, i.e., they will have imprecise boundaries. We will use language games [3] to put further constraints on the clustering procedure and to simulate the formation of concepts in a population of agents.

References

[1] Harnad, S. 1990. The symbol grounding problem. *Physica D: Nonlinear Phenomena*, 42(1), 335-346.

[2] Gärdenfors, P. 2000. Conceptual spaces: The geometry of thought. *MIT Press*

[3] Steels, L. 2015. The Talking Heads experiment: Origins of words and meanings. *Vol. 1. Language Science Press*.