1996

Behavior-Based Analogy-Making

Doug Blank
Bryn Mawr College, dblank@brynmawr.edu

Custom Citation
Blank, D.S. (1996). Behavior-Based Analogy-Making. Proceedings of the Eighteenth Annual Cognitive Science Society Conference.

Behavior-Based Analogy-Making

Douglas S. Blank
Department of Computer Science
Indiana University
Lindley Hall 215
Bloomington, IN 47408
blank@cs.indiana.edu

Most everyone, including the experts, would agree that analogy-making is best defined as a process that creates a mapping between items in one domain (often called the *source*) to "similar" items in another domain (often called the *target*). Based on this definition, many researchers have attempted to model analogy-making by creating a mapping between two sets of data structures that represent the domains (Gentner, 1983; Holyoak and Thagard, 1989).

Defining analogy-making as "making a mapping between domains" creates many assumptions about analogy and how one might model it. For instance, the traditional view assumes that there exist pre-structured representations on which the mapping process operates. It is not at all clear that this assumption is cognitively plausible (Chalmers *et al*., 1995). This view also suggests that not only can the mapping process be separated from the structure-forming process, but that it is also distinct from more general perceptual processes. This, too, seems unlikely. Although these issues have been partially addressed by Hofstadter and colleagues (1995), one question remains: How could a system *learn* to make analogies?

To create a model capable of learning to make analogies requires re-thinking some basic assumptions. Traditionally, "making an analogy" has meant explicitly producing the entire set of correspondences from one domain to the other. It is difficult to see how a system could learn to do this.

One possible solution, following the general suggestions of Maes (1993), is to frame the task in terms of behavior. One analogy-making task that can be seen entirely in terms of behavior is the "Do this!" task posed by Hofstadter and French (French, 1992). A boiled-down version of this task was defined as follows. Consider Figure 1. Imagine an experimenter pointing to the triangle in the source scene and saying, "Do this!" The subject's task is then to point to the "same" thing in the target scene. If one perceives the triangle as "the object that differs on the dimension of shape," then one might be inclined to choose the square in the target scene, as it, too, differs by shape from the two circles in the target scene. Of course, that is certainly not the only possible answer.

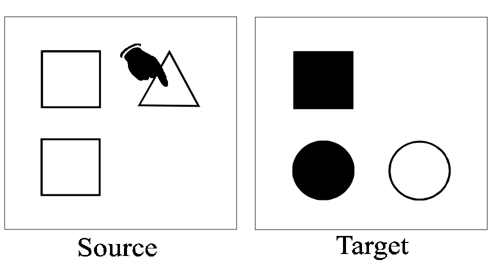

Figure 1. A sample problem adapted from French (1992).

To learn to make this type of analogy, a recurrent backpropagation network was created. A variation on Smolensky's tensor product representation (1990) was developed and used as input to the network. These representations, termed *iconic*, encode an object's location in a scene over a set of local units. A series of these iconic maps, in turn, encodes an object's color and shape, such as *blue* and *square*.

The network was trained to identify the *figure* and *ground* of each scene presented to it. The network was first trained to identify the object being pointed to in the source scene as the figure, and the remaining source objects as the ground. Given the first scene as context, the network was then trained to identify the analogous object from the target as the figure, thereby completing the analogy.

After being successfully trained on many example analogies, the network was shown to generalize by performing well on many novel scenes. Analysis has shown that the network is capable of learning abstract "concepts" such as "differs by shape." Although the current model has some significant limitations, it does suggest a framework for a behavioral approach of analogy-making capable of explaining effects such as "systematicity" (Gentner, 1983) and unifying analogy-making with more general perceptual processes.

References

Chalmers, D., French, R., and Hofstadter, D. (1995). High-level perception, representation, and analogy: a critique of artificial-intelligence methodology. In *Fluid concepts and creative analogies*. Basic Books, New York, NY.

French, R. (1992). *Tabletop: An emergent, stochastic model of analogy-making*. Doctoral dissertation, EECS Department, University of Michigan, Ann Arbor.

Gentner, D. (1983). Structure-mapping: A theoretical framework for analogy. *Cognitive Science*, 7(2).

Hofstadter, D. and the Fluid Analogies Research Group (1995). *Fluid concepts and creative analogies*. Basic Books, New York, NY.

Holyoak, K., and Thagard, P. (1989). Analogical mapping by constraint satisfaction. *Cognitive Science*, 13(3).

Maes, P. (1993). Behavior-based artificial intelligence. In Proceedings of the Fifteenth Annual Conference of the Cognitive Science Society. Boulder, CO.

Smolensky, P. (1990). Tensor product variable binding and the representation of symbolic structures in connectionist systems. *Artificial Intelligence*, 46.