CS 786G *Cognitive Modeling*
Week 5 Discussion Paper
Learning by Analogy

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Gentner (1981) decomposes the large process of analogical learning into several subprocesses: *accessing* the potential (base) analog, *completing a mapping* between base analog and target, *evaluating* the match for analogical soundness, *storing inferences* in the target, and sometimes *extracting* the commonalities.

Access basically determines how the large possible set of experiential knowledge is indexed to suggest possible candidate base analogs. Research has indicated that matches at this level are strongly dependent on surface characteristics similar between base and target rather than the deeper relational correlations.

Mapping is the overlay of the base analog to the target so as to allow the inference of new information about the target according to the structure of the base. If the agent creating the analogy is well versed in both the base and target domains, little *new* information is typically gleaned about the target itself, while if the agent is naive in the target domain, new information may likely be "carried-over" from the base domain.

If we consider access as a filtering approach which narrows the range of possible matches, and mapping and evaluation as the attempt to locate the "better" or more relevant base-target analog while considering a deeper level of structure and relation, then it is clearly possible that the "best" match or most structural related match could be missed during access, specifically if the "best" base analog is in fact, superficially not similar to the target. Gentner states, reasonably enough, that there are many plausible explanations for this behaviour in humans. For instance, the size of the number of bases in a human memory could be too many in which to perform purely relational matching efficiently. Gentner proposes another possible explanation of this conservative matching strategy by noting that accessing a false-positive base is potentially more dangerous than failing to access a possible base at all. Supposedly what is meant is that supposing a false analog could lead one to erroneous inferences about one's environment and in such cases it would be better to fall back about "lower", presumably more cautious levels for determining action. It is not clear to this reader precisely what these other levels of determining action might be, and consequently it is difficult to estimate the utility of such an approach, however, it would seem to correspond to the case where one experiences an essentially "unique" situation, previously unseen. The question of whether one is better off planning from first principles or adopting a potentially incorrect analogy appears to deserves more investigation from the point of view of designing robust reasoning systems for autonomous agents that may live in dangerous environments.

The inability to wade through a lifetime's worth of experiences to access a particular analogical base has much similarity with other real-world problems in AI. Many decision support systems are built around methods of assisting human experts determine which of a mass of information is relevant. The problem can be either the size of the knowledge base, or potentially the complexity of the problem itself that overwhelms the human capacity for recognizing interacting relationships. One example of the later in which approximation methods to access based on abstraction have proven useful is described in Woods (1993). Here a problem domain known as Spatial Template Recognition is described in which one is given a template consisting of a set of slots with 2D spatial attributes (such as position, and orientation) as well as identifying attributes (such as type or color) and which have a set of relative position constraints among the slots (such as relative alignment, or separation). The problem lies in identifying instances of the template in a given situation consisting of many partially attributed *situation elements* which are candidates to be matched with a slot. A complete solution is a 1:1 mapping, from slot to situation element such that the slot attribute constraints and inter-slot spatial constraints are satisfied. An abstracted version of this approach consists of relaxing or removing some of the initial slot constraints so as to arrive at the "essential" or "important" aspects of the template and identify instances according to those constraints only, attempting to revise the set of solutions through subsequent re-addition of constraints, according to the control of a human expert. While the "best" solution in a particular case may be a partial solution that is missed as a result of the initial "abstracted" match, this model has proven to be attractive and explainable to human experts who have reported that they attempt purely manual searches in a similar fashion.

References

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