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# Intermediate Features Improve Incremental Analogical Mapping

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Previous work has suggested that certain descriptive elements may naturally be more informative and might be profitably used for certain sorts of cognitive tasks, such as object identification or precedent retrieval. We call these descriptive elements *intermediate features* because the evidence suggests that the most informative features are those of an intermediate size and complexity. (Finlayson & Winston, 2005; Ullman, Vidal-Naquet, & Sali, 2002)

We now have demonstrated the utility of intermediate features in another cognitive task—constructing an analogical mapping—by showing that an incremental analogical mapper that focuses on first mapping intermediate features performs on average significantly better than other benchmark incremental analogy models. Data is shown in Figure 1, where it can be seen that our BIA (the *Bridge Incremental Analogizer*, our intermediate-feature-based mapper) performs significantly better than two other incremental analogical mappers, SME, the Structure Mapping Engine (Forbus, Ferguson, & Gentner, 1994; Falkenhainer, Forbus, & Gentner, 1989), and IAM, the Incremental Analogy Machine (Keane, Ledgeway, & Duff, 1994).

Incremental mappers differ from full analogical mappers in that they attempt to quickly narrow the possible field of analogies and produce the best analogies first, rather than a number of (or all) analogies in parallel. Algorithmically, incremental mappers can be seen as producing a queue of analogies as their output, with analogies deemed best near the front of the queue, and analogies deemed poor nearer the back.

We implemented both the SME and IAM incremental analogical mappers from their descriptions in the literature. The BIA is the same as IAM, except that, significantly, it first maps the head nodes of intermediate-sized features to produce seed matches. To produce Figure 1 we used a dataset of our own construction that consists of 14 descriptions of international and civil conflicts. These are cast in a relatively standard node-with-frame representation, where nodes represent objects and relations, and each node has an associated frame which contains semantic information. Each mapper was run with all description pairings (except self-pairings), resulting in  $14 \times 13 = 182$  analogies computed for each index of the queue. For each pair of descriptions, the mappers were used to produce a queue of forty analogies, and then each analogy was scored using a standardized rating

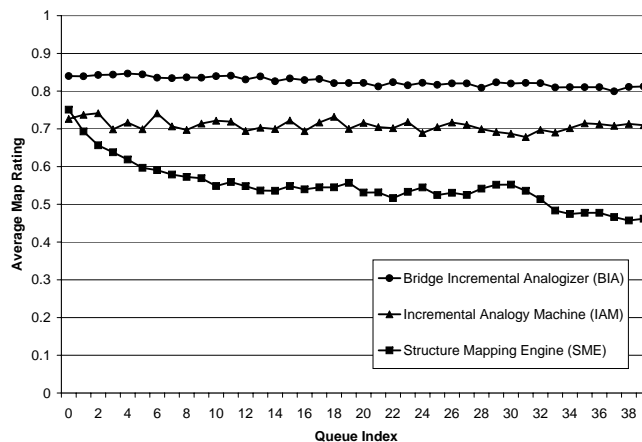


Figure 1: Data showing that the first forty analogies produced by the BIA incremental mapper are, on average, significantly better than those produced by IAM or SME. The dataset was 14 descriptions of international and civil conflicts, giving 182 analogies for each data point.

method (Falkenhainer et al., 1989) and the results were normalized against the highest-rated analogy in all three queues. Finally, all 182 sets were averaged by queue index to produce the results in Figure 1.

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