Connectionist taxonomy learning

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1 Introduction

The paper at hand describes an approach to automatise the creation of a class taxonomy. Information about objects, e.g. "a tank is armored and moves by track", but no prior knowledge about taxonomy structure is presented to a connectionist system which organizes itself by means of activation spreading (McClelland and Rumelhart, 1981) and weight adjustments. The resulting connectionist network has a form of a taxonomy sought–after.

2 Creating a taxonomy

The creation of taxonomy from input data is a two–step operation. At first, a raw taxonomy, reflecting only input data, is built up. This process incorporates two kinds of learning (after Sowa, 2002): *rote learning* used to store input data in the network and *restructuring* by creating or removing nodes and connections. Then an additional introspective process complements the taxonomy with newly discovered nodes (further restructuring).

Step 1: creating raw taxonomy. In the first step, the presented data is encoded in feature and class nodes mutually connected with excitatory connections. Based on the data stored, the hierarchy is created. For each pair of class nodes both nodes are subsequentially activated and activation is spread to the feature nodes layer. The activation patterns are subsequently compared along the basic assumption that a subclass contains all features of its superclass and at least one more distinctive one. The "class — superclass" relation emerges from this comparison. Finally, inhibitory connections are introduced in a way to enhance differences in input data.

Step 2: restructuring the network. The network created so far is structured only as far as it is provided by the original input data (fig. 1). The next step towards a better taxonomy is to "discover" other parts of the hierarchy which were not provided explicitly. The way in which the network is created ensures that the difference between classes is maximized by the

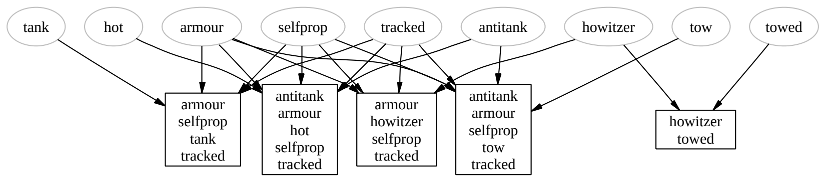

Figure 1: Raw network. Nodes with grey outline denote features, boxed nodes stand for input data.

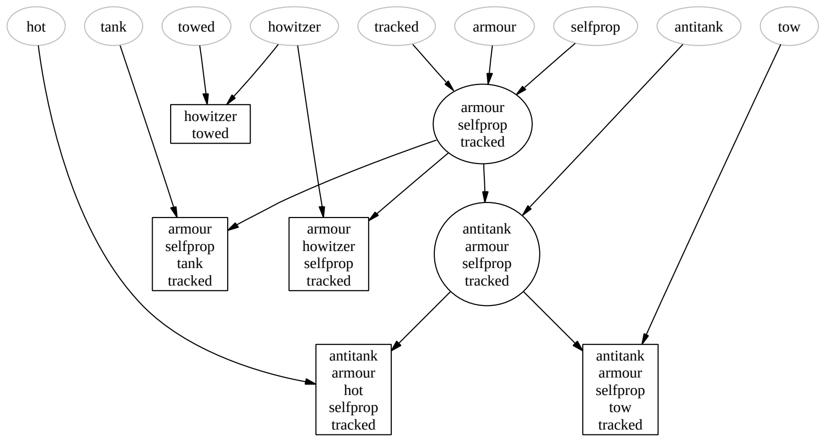

Figure 2: Full hierarchy. Elliptic black nodes denote discovered classes.

inhibition mechanism. Thus if two class nodes are activated, the activation spreading mechanism allows to activate only common feature nodes. Those nodes serve as a new descriptions for class nodes. The result of this operation is a new taxonomy, which contains nodes denoting data present in original dataset enriched with the discovered hierarchy nodes (fig. 2).

3 Features of the network

Description auto completion and noise reduction. The network manifests an autoassociation property. Given a part of description (the incomplete set of features) it attempts to complete it in the best possible way: it recalls the features set (in a way that it activates corresponding nodes) for which the given features are the most distinctive. The noise reduction feature is displayed in a case when a network is fed with data containing features that do not co-occur with other ones. In case the other features define the class sufficiently, the corrected pattern is reproduced and the activation of "noise features" is cancelled.

Generalization. Generalization takes place when the given data contains features that are contradictory but still correspond to nodes in the same taxonomy branch. In this situation a network converges to the feature pattern describing the superclass which is common for all nodes partially described by the given data. In other words, the network finds a more general term to describe the presented set of features. This mechanism allows for classification of novel datasets.

Family resemblance. In the resulting network not all members of a category must have features common to the other members. Membership is based on *family resemblance* (e.g. Rosch, 1975). In the example taxonomy (fig. 2) the classes *"howitzer towed"* and *"armour selfprop tank tracked"* have no common features but still are contained by the same category. The family resemblance can be measured in presented model in terms of activation.

4 Conclusions

A connectionist system to create taxonomies from example definitions has been presented. The system is able not only to reflect the structure of the input data but also to discover underlying relations. In addition, it displays autoassociation properties, it is able to generalize, and it models family resemblance. The presented method uses activation spreading networks. This novel approach can be used to support the automatic creation of an ontology (cf. Gomez-Perez and Manzano-Macho, 2003).

References

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