

Combining Symbolic and Connectionist Techniques for Coordination in Natural Language

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Abstract

This paper describes a hybrid symbolic/connectionist system which combines symbolic and connectionist techniques for the structural interpretation of noun phrases. Using coordination (grammatical structures with conjunctions like “and”) as a representative problem for a whole class of attachment problems, we describe a system which integrates syntactic and semantic knowledge for parsing “real world” text from a scientific technical corpus. Our hybrid model consists of a symbolic chart parser for parsing noun phrases, a symbolic preference module for semantic expectations, and a connectionist backpropagation network for semantic coordination relationships. We show that a symbolic syntactic parser and a connectionist semantic memory model can interact for resolving coordination problems.

1 Introduction

Recently, there has been a lot of discussion about advantages and disadvantages of connectionist concepts for natural language processing (e.g., [Dyer 88] [Diederich 88] [Freksa 88] [Lehnert 88] [Höppner 88]). In this paper we investigate the combination of symbolic and connectionist techniques for the representation and coordination of noun phrases. The coordination of constituents with conjunctions like “and” belongs to the most difficult and important problems in natural language processing (e.g. [Dahl and McCord 83] [Fong and Berwick 85]). In the past there have been mainly syntactic approaches for coordination in simple declarative sentences ([Fong and Berwick 85] [Peterson 81] [Van Oirsouw 87]). Although there are some approaches which use syntax and semantics [Huang 83] [Lesmo and Torasso 85], many approaches are syntactic and use verb-related case information to resolve some forms of coordination within sentences. However, in some cases like isolated noun phrases, syntactic verb-related information is not available or sufficient to resolve coordination problems. Noun phrases are extremely frequent, e.g., in titles of papers and books, in queries to databases, and in standard documents like medical records. In noun phrases it is not possible to rely exclusively on syntactic constraints. For instance, the following two noun phrases have the same syntactic word classes, but because of semantic knowledge “children and women” are coordinated in example (1) and “hills and mountains” in example (2).

(1) Children on hills and women

(2) Children on hills and mountains

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We will describe a new hybrid model for coordination in noun phrases. Hybrid models for language understanding [Lehnert 88] [Wermter 89a] [Hendler 89] use different knowledge representations to support different forms of processing. Our hybrid model combines a syntactic chart parser for noun phrases with a semantic preference module and with a semantic connectionist network. The parser uses context-free rules to produce a preliminary structure of the noun phrase. The preference module contains simple frame-like representations for words which can predict following constituents. The connectionist network is a backpropagation network which is trained with coordination relationships and which produces a plausibility measure for the coordination of two constituents. The overall strategy is to combine *predefined* syntactic rules and semantic preferences with *learned* plausibilities of coordination relationships.

2 Syntactic and Semantic Constraints for Coordination

In this section we describe syntactic and semantic constraints which are involved in understanding coordination in noun phrases. We illustrate the constraints with examples from the NPL corpus [Sparck-Jones and VanRijsbergen 76] which contains titles and abstracts from the physical sciences. Within noun phrases some cases of coordination can be detected with **syntactic constraints**. Consider the following noun phrases:

- (3) Observation of single and double inflexions
- (4) Electron collision frequencies in nitrogen and in the lower ionosphere
- (5) Physical state of outer atmosphere and the origin of radiation belts

Example (3) shows that syntactic knowledge about word classes can be used to decide that adjectives are coordinated. Since “single” and “double” are adjectives they are both modifiers of “inflexions”. Another example for the use of syntactic knowledge is the explicit repetition of function words like prepositions. In example (4) “in nitrogen” and “in ionosphere” are coordinated. If the second “in” would have been left out, then “electron collision frequencies” and “ionosphere” could be coordinated as well. The repetition of a preposition is a strong syntactic constraint that the constituents following the prepositions are coordinated. Other syntactic constraints involve the use of determiners and symmetry. For instance, in noun phrase (5), the use of the determiner “the” increases the plausibility that “state” and “origin” are coordinated and not “atmosphere” and “origin”. Furthermore, the symmetric structure of the two headnouns “state” and “origin” each modified by a single prepositional phrase with the preposition “of” supports this structural interpretation as well.

Besides the syntactic constraints, **semantic constraints** are important for the interpretation of coordination. Sometimes preferences are associated with a certain word and set up an expectation for constituents which might follow. The following two examples illustrate two preferences.

- (6) A relation between giant travelling disturbances and sporadic E ionization
- (7) Possible explanation of the coexistence of ferromagnetism and superconductivity