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APPLICANT

GEORGE HEIDORN, BELLEVUE, WA; KAREN JENSEN, BELLEVUE, WA.

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SEED AND BERRY
6300 COLUMBIA CENTER
SEATTLE WA 98104-7092

TITLE

METHOD AND SYSTEM FOR COMPUTING SEMANTIC LOGICAL FORMS FROM SYNTAX TREES

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Description

METHOD AND SYSTEM FOR COMPUTING SEMANTIC LOGICAL FORMS FROM SYNTAX TREES

Technical Field

The present invention relates to the field of natural language processing ("NLP"), and more particularly, to a method and system for generating a logical form graph from a syntax tree.

Background of the Invention

Computer systems for automatic natural language processing use a variety of subsystems, roughly corresponding to the linguistic fields of morphological, syntactic, and semantic analysis to analyze input text and achieve a level of machine understanding of natural language. Having understood the input text to some level, a computer system can, for example, suggest grammatical and stylistic changes to the input text, answer questions posed in the input text, or effectively store information represented by the input text.

Morphological analysis identifies input words and provides information for each word that a human speaker of the natural language could determine by using a dictionary. Such information might include the syntactic roles that a word can play (*e.g.*, noun or verb) and ways that the word can be modified by adding prefixes or suffixes to generate different, related words. For example, in addition to the word "fish," the dictionary might also list a variety of words related to, and derived from, the word "fish," including "fishes," "fished,"

"fishing," "fisher," "fisherman," "fishable," "fishability," "fishbowl," "fisherwoman," "fishery," "fishhook," "fishnet," and "fishy."

Syntactic analysis analyzes each input sentence, using, as a starting point, the information provided by the morphological analysis of input words and the set of syntax rules that define the grammar of the language in which the input sentence was written. The following are sample syntax rules:

sentence = noun phrase + verb phrase

noun phrase = adjective + noun

verb phrase = adverb + verb

Syntactic analysis attempts to find an ordered subset of syntax rules that, when applied to the words of the input sentence, combine groups of words into phrases, and then combine phrases into a complete sentence. For example, consider the input sentence: "Big dogs fiercely bite." Using the three simple rules listed above, syntactic analysis would identify the words "Big" and "dogs" as an adjective and noun, respectively, and apply the second rule to generate the noun phrase "Big dogs." Syntactic analysis would identify the words "fiercely" and "bite" as an adverb and verb, respectively, and apply the third rule to generate the verb phrase "fiercely bite." Finally, syntactic analysis would apply the first rule to form a complete sentence from the previously generated noun phrase and verb phrase. The result of syntactic analysis, often represented as an acyclic downward branching tree with nodes representing input words, punctuation symbols, phrases, and a root node representing an entire sentence, is called a parse.

Some sentences, however, can have several different parses. A classic example sentence for such multiple parses is: "Time flies like an arrow." There are at least three possible parses corresponding to three possible meanings of this sentence. In the first parse, "time" is the subject of the sentence, "flies" is the verb, and "like an arrow" is a prepositional phrase modifying the verb "flies." However, there are at least two unexpected parses as well. In the second parse, "time" is an adjective modifying "flies," "like" is the verb, and "an arrow" is the object of the verb. This parse corresponds to the meaning that flies of a certain type, "time flies," like or are attracted to an arrow. In the third parse, "time" is an imperative verb, "flies" is the object, and "like an arrow" is a prepositional phrase modifying "time." This parse corresponds to a command to time flies as one would time an arrow, perhaps with a stopwatch.

Syntactic analysis is often accomplished by constructing one or more hierarchical trees called syntax parse trees. Each leaf node of the syntax parse tree generally represents one word or punctuation symbol of the input sentence. The application of a syntax rule generates an intermediate-level node linked from below to one, two, or occasionally more existing nodes. The existing nodes initially comprise only leaf nodes, but, as syntactic analysis applies syntax rules, the existing nodes comprise both leaf nodes as well as intermediate-level nodes. A single root node of a complete syntax parse tree represents an entire sentence.

Semantic analysis generates a logical form graph that describes the meaning of input text in a deeper way than can be described by a syntax parse tree alone. The logical form graph is a first attempt to understand the input text at a level analogous to that achieved by a human speaker of the language.

The logical form graph has nodes and links, but, unlike the syntax parse tree described above, is not hierarchically ordered. The links of the logical form graph are labeled to indicate the relationship between a pair of nodes. For example, semantic analysis may identify a certain noun in a sentence as the deep subject or deep object of a verb. The deep subject of a verb is the doer of the action and the deep object of a verb is the object of the action specified by the verb. The deep subject of an active voice verb may be the syntactic subject of the sentence, and the deep object of an active voice verb may be the syntactic object of the verb. However, the deep subject of a passive voice verb may be expressed in an agentive-by phrase, and the deep object of a passive voice verb may be the syntactic subject of the sentence. For example, consider the two sentences: (1) "Dogs bite people" and (2) "People are bitten by dogs." The first sentence has an active voice verb, and the second sentence has a passive voice verb. The syntactic subject of the first sentence is "Dogs" and the syntactic object of the verb "bite" is "people." By contrast, the syntactic subject of the second sentence is "People" and the verb phrase "are bitten" is modified by the agentive-by phrase "by dogs." For both sentences, "dogs" is the deep subject, and "people" is the deep object of the verb or verb phrase of the sentence. Although the syntax parse trees generated by syntactic analysis for sentences 1 and 2, above, will be different, the logical form graphs generated by semantic analysis will be the same, because the underlying meaning of the two sentences is the same.

Further semantic processing after generation of the logical form graph may draw on knowledge databases to relate analyzed text to real world concepts in order to achieve still deeper levels of understanding. An example

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