The Use of Fuzzy Sets in Modelling Natural Language Semantics

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In this paper, we outline the main features of the Alternative Mathematical Model of Natural Language (AML) which was described in more details in /Nov 2/. It stems from the results of classical linguistics, namely from the Functional Generative Description of natural language (FGD) which is being developed by Prague linguistic group leaded by P. Sgall /SgHaPa/. FGD describes natural language by a system of levels. The highest one, tectogrammatical level, is a level of meaning which serves as basis of AML. In this sense, AML is an extension of FGD.

Basic assumptions of AML

Objects which are reffered to in the model are sets taken from the universal class V of all sets. This means that all the objets in the reality are replaced by sets. The elements of sets are attributes of objects by means of which they can be distinguished. Lexical meaning of a word is generally a fuzzy set which is adjoined to a nebula (see /Pul/)

$$N = \langle\langle U, \nu\rangle , K, U\rangle ,$$

where U is a universe, K is a kernel (a set of prototypes) and $\nu : U \times U \to L$ is a relation of L -nearness. Using L-nearness we acquire the meaning of a notion determined by some property p and being vague.

Semantic universe is a class

$$U_\mathcal{S} = \{N;\ N \text{ is a lexical meaning of a word, designation or sentence}\}$$

The meaning of a sentence (utterance) is a structure expressed by a tree whose root is a verb(a certain fuzzy set) and branches are characterised by some fuzzy sets which are generated in a specific way in time.

Nouns are names of properties of sets, i.e. in our interpretation they are fuzzy sets.

$$(S, g, \{\text{indef}, \text{plur}\}) = F_S \subseteq U_S$$

where g denotes the membership of g in topic (t) or focus (f), indef is the grammateme of indefinite delimitation and plur the grammateme of number (plural). Other combinations of grammatemes lead to various fuzzy sets or elements from U_S.

Adjectives are also names of properties of sets. They differ from nouns by their role in the sentence. Lexical meaning of an adjective A is

$$(A, g, \text{pos}) = F_A \subseteq U_A$$

where pos is the grammateme of degree (positive). Original adjectives are such that F_A does not belong to the semantic universe. AML contains also the theory of joining adjectives and nouns together, qualitive adjectives and other degrees of adjectives (comparative and superlative).

Verbs are modelled by fuzzy sets of fuzzy relations. A frame of a verb V is a set

$$MR_V \subseteq \{U_{Act}, U_{Obj}, U_{Eff}, U_{Addr}, \dots\}$$

where U_{Act}, U_{Obj}, U_{Eff}, U_{Addr}, ... are universes for actor, objective, effect, addresse and various modifications (see

/SgHaPa/). The meaning of a verb V is a fuzzy set

$$(V, g, \ldots) = \{ V(F)/F;\ F \lesssim \mathcal{F}(\times MR_V) \}$$

where V(F) is the degree in which the activity (fuzzy relation) F has the property V of the verb.

Time, a charactiristics of verb, is given by a function

$$t : \mathbb{R} \longrightarrow \mathcal{F}(\times MR_V)$$

and fuzzy set $T \lesssim \mathbb{R}$ which induces a fuzzy set

$$t(T) \lesssim \times MR_V .$$

In AML it is demonstrated how to realise complementation of verb and also various grammatemes of a verb.

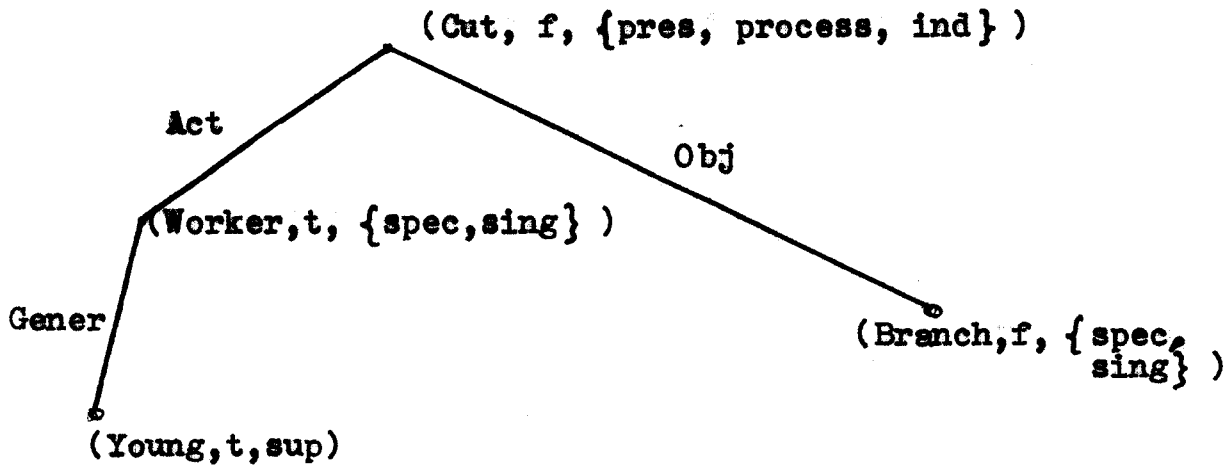
Adverbs from a non-homogenous group. . D-adverbs express the degree of property (in fuzzy set theory they are known as linguistic hedges). The meaning of an adverb is a couple of functions

$$\langle f_m,\ \nu_m \rangle$$

where $f_m : U \longrightarrow U$ is a displacement of membership function and $\nu_m : L \longrightarrow L$ its modification.

Example

The youngest worker cuts a branch



The meaning of this sentence is a fuzzy set of fuzzy relations

$$F_{VP} = \{Cut(F_C)/F;\ F \subseteq U_{Act} \times U_{Obj},\ F\langle x,y\rangle = F_{YW} \times 0_1 F_{Br} y 0_2 0_2 F_C\langle x,y\rangle\}$$

where $F_{YW} = F_W \times 0_3 F_Y z$, $z \in x$ (age, attribute of x) and $0_1, 0_2, 0_3$ are some operations with membership degrees (e.g.minimum).

References

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