FUZZY SEMANTIC NETWORKS: A NEW KNOWLEDGE REPRESENTATION STRUCTURE

BY:

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ABSTRACT

This paper introduces a new method of knowledge representation called a fuzzy semantic network (FUSEN). FUSENs were created to model continuous or fuzzy knowledge using concepts from artificial intelligence, fuzzy set theory, and cognitive psychology.

FUSENs have the ability to model three theories from cognitive psychology: the theory of natural categories, the family resemblance theory, and the feature-set theory. They can also perform as most of the knowledge structures from artificial intelligence and as a fuzzy set structure. Presented is their structure and several examples illustrating their use.

INTRODUCTION

To have a complete understanding of an entity one must be aware of how it acts, what rules apply to it, and in what situations one might expect to find it. For example, it is possible to describe the color, shape, size, and subparts of a 'dog'. It is easy to define the sets to which 'dog' belongs and the memebers of the set called 'dog'. But, the concept of 'dog' is not complete unless one knows what 'dog's do and how they act. There should be specific memories of 'dog's. There should be anticipations of what to expect from 'dog's in general and from specific 'dog's in particular. There must also be an understanding of time, space, and the physical reality in which 'dog's operate. A complete concept of a 'dog' includes all of this knowledge.

FUSENs divide this complex knowledge into four separate classes: entities and categories; actions and processes; literal and deep sentences; and rules and hypotheses. This paper examines the first of these classes and briefly discusses the relationships between FUSENs and three theories from cognitive psychology: natural categories, family resemblance theory, and feature-set theory.

STRUCTURE

Figure 1 shows the graphical representation of FUSENs. The owner label defines the owner of a head node and the type label defines the association existing between the node. The weights represent the association strengths between nodes. A head node can be associated with any number of sub-nodes. Each instance of a head node and its sub-nodes is called a fuse. All nodes of a fuse can be sub-nodes or head nodes of other fuses.

Figure 2 is a fuse representing a set of attributes for the category 'fruit'. This is determinded by examining the head node name, 'fruit'; and the type label '(attrib)'. The type label is a reserved work, denoted by the surrounding parentheses, describing the relationship between the sub-nodes and the head node. '(Attrib)' defines all the sub-nodes as attributes of the head node name 'fruit'. The owner label defines the parent node(s) of the head node. This label resolves any ambiguity created when two or more fuses have the same head node name. For example, if two fuses have the head node name of 'color', one would look at the owner label to see what they referenced. There could be fuses concerned with automobile colors, leaf colors, or colors is general. In Figure 2 the owner label is '()' or null. This means this fuse is about 'fruit' in general.

Each sub-node is a different attribute of 'fruit'. The weights associated with each sub-node reflects how strongly that particular attribute is associated with 'fruit'. The link labels define the domain over which the sub-node is defined. In Figure 2 'red' and 'yellow' are defined as colors of 'fruit'.

The weights are viewed as frequency counts. In Figure 2 the head node weights of 137 states that 137 instances of 'fruit' have been observed. The ratio of the sub-node's weight to the head node weight is that sub-node's association strength. 'Red' has an association strength of 66/137 or 48.2%.

Figure 3 shows a fuse representing a set of apples attributes. The type label is '(attrib)', so the syntax of this fuse is the same as that of Figure 2.

NATURAL CATEGORIES

The theory of natural categories was developed by Rosch [ANDE80]. Natural categories are levels of abstraction that people seem to naturally develop and use. Rosch feels categorization occurs to go beyond insignificant individual differences and to obtain the most information from the smallest amount of categorization.

Figures 2 and 3 can be used as an example of natural categories. According to these figures, a certain object that is small, red, and sweet can be seen as an apple or a piece of fruit. Since these attributes match both the 'apple' and the 'fruit' fuses a computer algorithm would say the object is both an apple and a piece of fruit, which is correct. But, in communicating with humans, the algorithm will have to pick the most appropriate level of abstraction or as Rosch called it, the 'basic' level.

The way the algorithm can find the basic level is to look at the head node weight. The highest weight is the most frequently conceptualized concept or the basic level. In this example the object would be called an 'apple'.

FAMILY RESEMBLANCE THEORY

The family resemblance theory was also developed by Rosch [ANDE80]. This theory states that every category is defined by an open-ended set of attributes or features. Natural categories have no fixed boundaries. For any particular category there might not be even one attribute in common with all the category members. An entity is judged to be a good member of a category if it has many attributes overlapping with the attributes of the category.

The FUSEN structure models this theory very well. The 'fruit' and 'apple' fuses show how the concept is defined by a set of attributes. The number of sub-nodes and their weights are dynamic and can constantly change as new examples of the category are observed. If a green fruit is observed, the sub-node 'green' with a weight of 1 will be added to the 'fruit' attribute fuse. In addition the 'fruit' head node weight will be incremented by 1.

FEATURE-SET THEORY

Feature-set theory [ANDE80] assumes people recall how frequently they have seen all the various attributes of a concept. The more frequently seen attributes have a higher correlation or association strength with the category.

This is exactly how fuses work. Figures 2 and 3 show two categories. The association strengths for each sub-node reflects how strongly it is associated with the head node. Notice that 'red' is more strongly associated with 'apple' than 'fruit', and 'tart' is more strongly associated with 'fruit'.

OTHER METHODS OF KNOWLEDGE REPRESENTATION

Sprague [SPRA82] has shown how fuses can also perform as many other knowledge structures. In particular he discusses production rules, semantic networks, expert knowledge systems, frame theory, fuzzy sets, and stimulus-response theory.

SUMMARY

This paper briefly introduces a new method of knowledge representation called a fuzzy semantic network. The theory is based on the idea that knowledge can be represented by the associations between symbols and that these symbols and associations can be explicitly represented by a semantic network. Using semantic networks as a base, a general method of knowledge representation was developed to include ideas from many areas: artificial intelligence, mathematics, psychology. It is hoped that when the complete syntax is developed FUSENs will be able to represent most any kind of semantic knowledge.

REFERENCES

[ANDE80] Anderson, J.R. 1980. Cognitive Psychology and Its Implications. San Francisco, CA: W.H. Freeman.

[SPRA82] Sprague, K.W. 1982. 'Fuzzy Semantic Networks'. Gainesville, FL: MS thesis University of Florida

Figures 2 and 3 on following page.

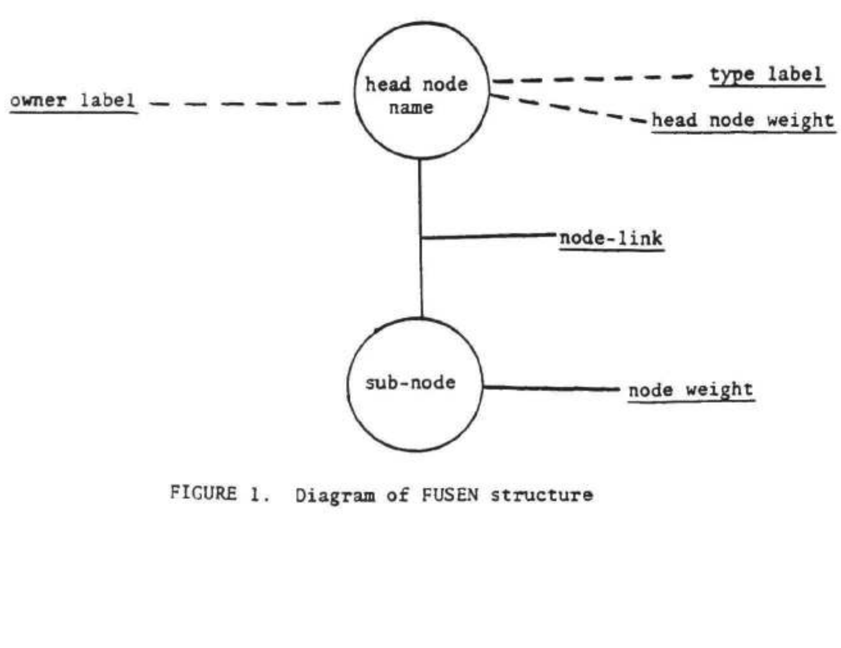

FIGURE 1. Diagram of FUSEN structure

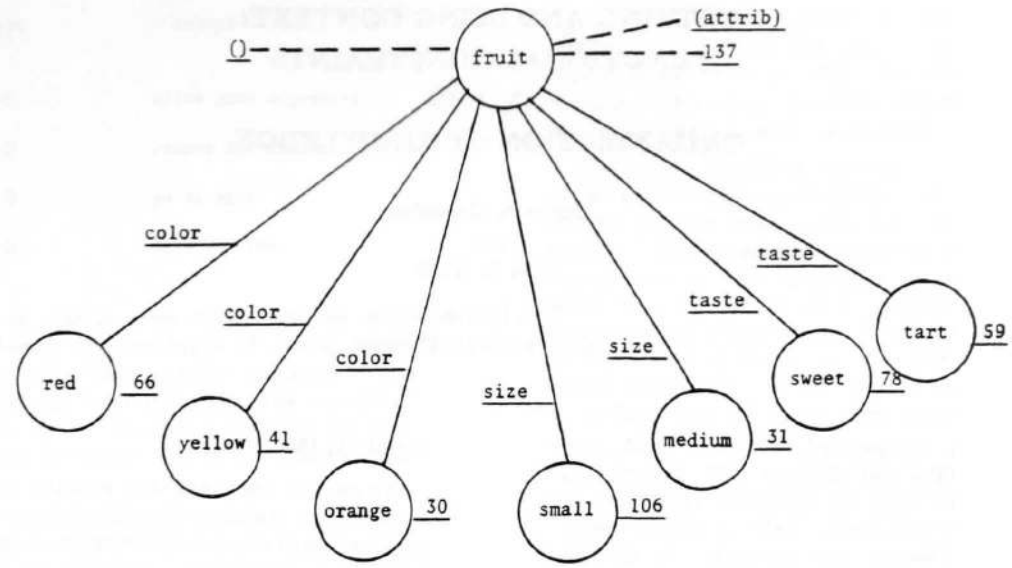

Figure 2. Example of fruit attribute fuse

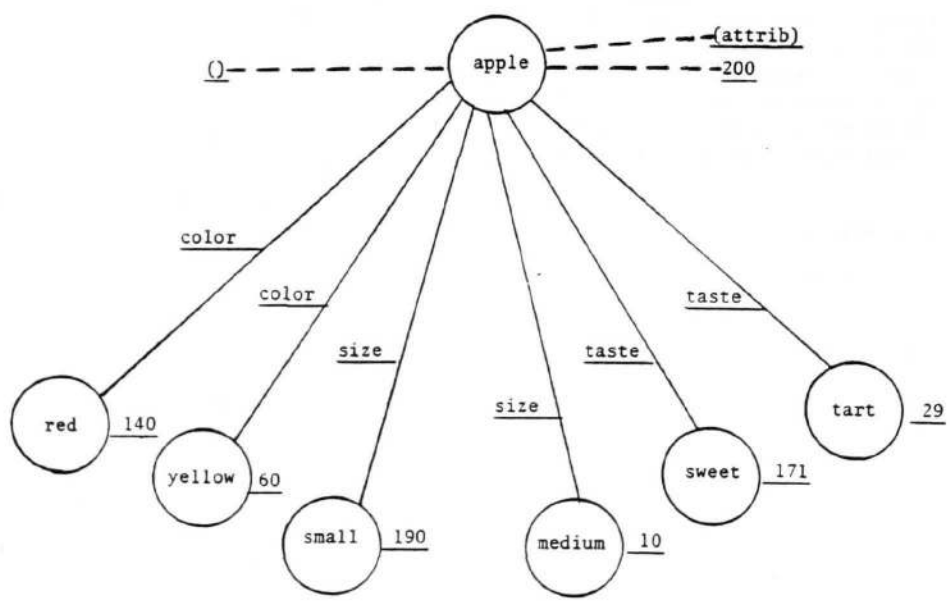

Figure 3. Example of apple attribute fuse