Viewing Semantic Networks as Hypermedia

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Abstract

The analogy of a semantic network to hypertext has long been recognized, and a semantic network has been considered as a logical model of hypertext – especially for those hypertexts with typed nodes and links. Moreover, wordnets form the most representative type of semantic networks in the field of Natural Language Processing and semantics in particular. It is obvious that hypertext and wordnets share many common points regarding their fundamental principles and the objectives towards which they both aim. In particular, they are both targeted towards capturing relations that possibly exist between objects and thus providing information of the underlying objects via various types of links used for describing the relations. In this respect, we strongly believe that if semantic networks are viewed beyond strictly linguistically constraints and applications, the results could only be beneficial.

1. Introduction

Hypertext[1] has always been closely related to the idea of freedom to associate, making it to be considered as an alternative means of structuring information. This new promising field provides its users (namely, authors and readers) with effective ways of presenting and exploring information. For authors, hypertext systems offer a high degree of flexibility for connecting pieces of information and presenting it as an assembled collection in an information network. For readers, hypertext provides tools for navigating in these information networks and for exploring them freely. Therefore, hypertext can be a precious dialogic means, facilitating the organization of information according to the user needs.

On the other hand semantic networks form a highly structured linguistic resource enabling a flexible navigation through the lexical items of a language. Wordnet forms a kind of conventional dictionary where semantic information of the terms it contains is represented. The main structural entities of wordnets are language internal relations through which words are linked based on their semantic properties. The main contribution of wordnets in lexicography is the systematic patterns and relations that exist among the meanings that words can be used to express. In this respect wordnets as a particular type of semantic networks resemble much hypermedia as far as the structural organization of information is concerned.

The paper is organized in the following way. Section 2 provides a brief overview of structure in semantic networks. In section 3, we reason about the ability of hypertext to structure information. Section 4 focuses on the similarities that hypertext and wordnets share, claiming that semantic networks can be viewed as hypertext. Finally, section 5 refers to the benefits that these two research areas may have if they are seen as a whole.

[1] Initially, hypertext dealt only with the manipulation of text. Nowadays, one can shape information structures containing pictures, video, sound, etc. Hypermedia – a contraction of the words *Hypertext* and *Multimedia* – is a name invented to stress this change of emphasis.

2. Structure in Semantic Networks

Wordnets form the most representative type of semantic networks in the field of Natural Language Processing and semantics in particular. Motivated by theories of human knowledge organization, wordnet emerged as a highly structured language repository, where words are defined relatively to each other. Unlike machine-readable dictionaries and lexica in book format, wordnet makes the commonly accepted distinction between conceptual-semantic relations, which link concepts and lexical relations, which link words (Evens, 1988). Thus, despite their resemblance to typical thesauri, wordnets in general clearly separate the conceptual and the lexical levels of language, and such a distinction is reflected via semantic-conceptual and lexical relations that hold among synsets and words respectively. Wordnets form semantic dictionaries that are designed as networks, partly because representing words and concepts as an interrelated system seems to be consistent with evidence for the way speakers organize their mental lexicons (Miller, 1998; Kay, 1989).

Wordnets' hierarchical structure allows a searcher to access information stored in lexical chains along more than one path, semantics being among them. Conceptual structures are modelled as a hierarchical network enabling a graphical representation of the lexicalized concepts when the latter are denominated by words (Priss, 1998). The theoretical analysis shows dependencies among semantic relations, such as inheritance of relations from sub-concepts to super-concepts. Therefore, related senses grouped together under the same lexical chain form preliminary conceptual clusters. Words belonging to the same lexical chain are connected via language internal relations, each one denoting the type of relation that holds among the underlying word meanings. Some of the language relations are bi-directional in the sense that if a link holds between term A and B then a link also holds between term B and term A. However, bi-directionality of the relations strongly depends on the language particularities and semantic properties of the underlying word meanings.

In order to account for particularities in lexicalized concepts, tags are assigned to each lexical relation denoting specialized semantic characteristics of a word's meaning. Tags can be viewed as a means of semantic constraints posed upon semantic relations that link word meanings rather than word forms. Moreover, tags provide information about which of the semantic properties represented in a lexical chain are inherited to its components. In this respect, words represent an atomic and unbiased level of individuality that becomes meaningful via anchoring of semantic relations. As Hasan (Hasan, 1984) pointed out, any word in a chain can be related to multiple other words in that chain. All lexical relations form a graph where cycles are disallowed since after all they contribute very little of any new information.

Summarizing, the structure of lexical data within wordnets is what differentiates the latter from traditional lexicographic aids (both dictionaries and thesauri). The motivation behind construction semantic networks in the form of a graph relies on the fact that lexical data becomes meaningful only via predefined linguistics structures. Navigation through the content of wordnets becomes feasible via language internal relations, which form the main notion around which structure is defined.

3. Hypermedia Principles of Structure

The term of hypertext cannot be explicitly defined since one can approach it by different directions. More specifically, there are those who claim that hypertext can be viewed as an interaction paradigm, referring to the manipulation of "pointing at a link and clicking it" in order to follow it. Additionally, there are others maintaining that "hypertext deals with the organization of information", regarding not only data but also structure as first-class user abstractions. Finally, there is another user group that considers "structure more important than data", making hypertext more structure-based technology than data-dependent.

Adopting the "primacy of structure over data" (Nürnberg et al., 1997), hypertext can be seen as a technology well suited to exploring different kinds of representational structures (Marshall, 1987). Viewing different parts of information as objects, users, often referred to as readers, can navigate through it in a more effective and convenient fashion. Additionally, authors can manipulate information according to their needs (Kyriakopoulou et al., 2001). Therefore, hypertext can be regarded as an informal mechanism, which describes the attributes of these objects and captures relationships that possibly exist between them. Such a characteristic made hypertext become known as an alternative way of structuring information.

Autonomous units of data (e.g. text, images, etc.) can be connected non-linearly creating a structure that has the form of a graph. Apparently, such type of organization and representation of information benefits not only the readers but also the authors, each one by their own point of view. More specifically, readers can retrieve the information they want in the right order serving more easily their particular needs, whereas authors can organize their ideas more efficiently by creating relationships (links) between parts of data (nodes). Thus, hypertext can be a precious dialogic means that offers more flexibility and the freedom of choice to the users according to their preferences, the level of comprehension, and other determined factors.

The analogy of a semantic network to hypertext has long been recognized (Conklin, 1987), and a semantic network has been considered as a logical model of hypertext – especially for those hypertexts with typed nodes and links. As it is widely known, a semantic network is a knowledge representation scheme consisting of a directed graph in which conceptual units are represented as nodes, and relations between the units are represented as links. The graph becomes semantic when each node and link is assigned a particular type, making it meaningful. The essential idea of semantic networks is that the graph-theoretic structure of relations can be used for inference as well as understanding (Lehmann, 1992). In this paper we claim that semantic networks may be profitably viewed as hypertext.

Trying to model different user needs in hypertext, the notion of domain appeared, defining special structural abstractions with specific properties as well as a set of behaviors. The role of structural abstractions is to capture and generalize the knowledge of different problem domains, whereas behaviors are described as computation over structure which is considered as a crucial parameter for the semantic of hypertext structure (Leggett and Schnase, 1994) (see table 1). For example, the idea of taxonomic domain was coined by biologists wanting support for the task of creating taxonomies of the species they were researching (Nürnberg et al., 1996). Similarly, within the last decades, various domains, such as navigational (Halasz, 1987), spatial (Marshall et al., 1994), argumentation (Conklin and Begeman, 1987), etc., have emerged. Since semantic networks and hypertext are closely related, the former ones may be considered as a new domain. The issue in hypertext upon the introduction of a new domain is not to express the domain structure using some general model of structure, but to provide users with domain specific structure to directly work with.

Taking the aforementioned into consideration, it is inferred that the need for domain existence in hypertext is essential. Towards the better exploitation of the properties provided by a particular domain, tools can be developed in order to utilize these specific structures. In this way, users can have the opportunity to work with these tools in order to perform syntactic and/or semantic checks, and maybe to perform structural computations that are only relevant within the domain. Therefore, semantic networks can possibly take advantage of these features improving the infor-

Domains	Structural Abstractions	Behaviors
Navigational	node, link, anchor	follow link, generic links
Taxonomic	taxonomy, taxon, specimen	open taxon, compare, auto generate, detect double categorizations
Spatial	item, space, implicit structure	spatial parse
Argumentation	issue, position, evidence	support link, oppose link, circular argument detection
Wordnet	synset	?

Table 1: Example domains in hypertext.

mation management and graph organization.

4. Approaching Wordnet via Hypermedia

Hypertext and wordnets share many common points regarding their fundamental principles and the objectives towards which they both aim. In particular, they are both targeted towards capturing relations that possibly exist between objects and thus providing information of the underlying objects via various types of links used for describing the relations. Therefore, the main characteristic of wordnets and hypertext systems is the ability to create associations between semantically related information items. On the one hand, these associations imply purposeful and important relationships between associated materials, whereas on the other hand the emphasis upon creating associations stimulates and encourages habits of relational thinking of the user (Landow, 1987).

Relations form the notion around which both semantic networks and hypertext are organized. In the case of semantic networks, relations are denoted explicitly between the lexical units they contain via predefined lexical links, and capture information on the semantic properties of words. In the case of hypertext, although the notion of association can be met in all hypertext domains, the navigational domain with the use of *links* is more closely related to it. Consequently, lexical relations form the fundamental entity of semantic networks the same way as associations in hypertext form the basic structural element around which domains are modeled.

In both cases, information objects (either lexical or not) are heavily structured in order to enable users of wordnets or hypertext navigate through the information they contain successfully. Structure is achieved via internal links, which form the basis on which information is stored and expressed. However, links in semantic networks and hypertext are until recently viewed as two distinct elements and no attempt has been made towards comparing the two. We report on the similarities that exist between hypertext relations and semantic links in an attempt to model the latter in hypertext systems.

In order to support this linking activity in an effective way, hypertext researchers have created a flexible link structure incorporating different levels of functionality. More specifically, in hypertext one can create single or bi-directional links, binary or n-ary links, links to links, automatically activated links, etc. Similarly, links in wordnet are bi-directional and there is generally no restriction on the number and types of links they could be included in it as long as the relatedness between the information items is properly and adequately expressed. Bi-directionality of links indicates that if an object A is somehow related to an object B then object B is again related via the same or another relation to the object A.

However, since bi-directionality might not always be the case in wordnets, special tags need to be attached to the relations to denote their single direction. Namely, tags are being used on semantic network relations to indicate that a lexical item is related to another via a particular type of link but not vice versa. Tags are attached to each link separately and act like constraints on the information provided by the link. However, in the case of hypertext, due to the existence of many specialized domains, the notion of tags is used implicitly.

Furthermore, besides creating associations among semantically related information items, another characteristic shared between hypertext and semantic networks is inheritance. This feature implies that properties of the father are inherited to the children. More specifically, the notion of generalization and specialization forms the principle on which relations are expressed. Specialization and generalization define a containment relationship between a higher-level entity set and one or more lower-level entity sets. Specialization is the result of taking a subset of a higher-level entity set to form a lower-level entity set, whereas generalization is the result of taking the union of two or more disjoint (lower-level) entity sets to produce a higher-level entity set.

Inheritance in wordnets is described via the *H/H tree* that is the complementary hypernymy/hyponymy relations. This type of relationship between objects result in viewing wordnets like tree-structured sources of information, and thus not allowing circular loops. As far as hypertext is concerned, these organizational structures exist in the taxonomic domain under the respective terminology of *supertaxon* and *subtaxon*. The subtaxon is associated with the supertaxon via an “is-a” relationship, inheriting all the characteristics that the latter might have. In particular, the user can classify objects (known as specimens) into sets according to their features, search within the members of a set to find relationships or discreet subsets, and create new sets from the already existing ones.

Finally, what should be stressed is that semantic networks and hypertext, despite the characteristics they have in common, they also have quite a few differentiations, mainly stemming from their applications and usage. What we attempted in this paper is to explore the usefulness of both wordnets and hypertext systems beyond the limitations imposed by the applications at which they are targeted. What we claim is that by treating wordnet, as a new domain of hypertext would result in a better understanding of the language structure and consequently human memory and way of thinking. After all, any application is targeted towards human beings and aims at providing a clear description of how information is stored and thus how it should be interpreted. In this respect we strongly believe that if semantic networks are viewed beyond strictly linguistically constraints and applications, the results could only be beneficial.

5. Discussion

As it has been already mentioned, the technology of hypertext is not mainly used for the organization of information but can be considered as a significant means of structuring information. Viewing semantic networks as hypermedia, the power of hypertext is enforced even more, making us infer that any kind of information can be structured under the fundamental characteristics of hypertext. Furthermore, some special structural characteristics of semantic networks can be effectively exploited by hypertext community, resulting in the extension of already existing domains, such as taxonomic, navigational, etc. More specifically, tags might be such a characteristic, providing the hypertext users with the ability to pose semantic constraints upon relations, enabling the distinction among different types of whichever kind links.

On the other hand, taking advantage of the structural characteristics of hypertext while developing semantic networks can prove quite beneficial for both the lexicographic and linguistic communities. In particular, hypertext provides ways of organizing information stored in such systems in a meaningful way so that navigation through the stored data is facilitated. By adopting structures implied by the hypertext community in other applications such as lexicography, the potential and performance of the latter can be greatly improved. When it comes to the storage of lexicographic data the need for efficient structures becomes apparent due to the large amount of information that has to be handled and especially due to the dynamic nature of the underlying information. Moreover, even if behaviors exist in wordnets, they haven't been explicitly defined so far, resulting in less comprehensive usage of the underlying data.

Language forms the mean through which communication is achieved and as such its processing undergoes through various structural decisions that need to be taken prior to storing and incorporating lexicographic data in applications. In this paper we attempted a preliminary comparison among structural characteristics of semantic networks with hypertext and as a conclusion we claim that the abovementioned areas share a few common points in terms of data representation, storage and navigation. What we imply is that semantic networks and hypertext are by no means equivalent in terms of structure. Conversely, what we suggest is that by tracing points between the two and by adopting structural characteristics of other domains can only be beneficial for both sides.

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