A 3D USER INTERFACE FOR THE SEMANTIC NAVIGATION OF WWW INFORMATION

Manuela Angioni, Roberto Demontis, Massimo Deriu and Franco Tuveri
CRS4 - Center for Advanced Studies, Research and Development in Sardinia, Polaris, 09010 Pula (CA), Italy

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Abstract: The automatic creation of a conceptual knowledge map using documents coming from the Web is a very relevant problem because of the difficulty to distinguish between valid and invalid contents documents. In this paper we present an improved search engine GUI for displaying and organizing alternative views of data, by the use of a 3D graphical interface, and a method for organizing search results using a semantic approach during the storage and retrieval of information. The presented work deals with two main aspects. The first one regards the semantic aspects of knowledge management, in order to support the user during the query composition and to supply to him information strictly related to his interests. The second one argues the advantages coming from the adoption of a 3D user interface, to provide alternative views of data.

1 INTRODUCTION

A web-based search engine responds to a user's query with a list of documents. This list can be viewed as the engine's model of the user's idea of relevance the engine 'believes' that the first document is the most likely to be relevant, the second is slightly less likely, and so on. In the specific context of the DART project (Angioni et al., 2007), that is focused in the development of a distributed architecture for a semantic search engine, we think that the answer to a query can be given providing the user with several kind of results, not always related in the standard way the search engines we use today do. A semantic approach for information storage and retrieval is a way to represent knowledge in the form of human language, similar as it is represented in the human mind, but while hyperlinks have come into widespread use, the closely related semantic link is not yet widely used. Semantic networks are a powerfull manner to represent knowledge. A semantic network is fundamentally a system for capturing, storing and transferring information that works much the same as (and is, in fact, modelled after) the human brain. It is robust, efficient and flexible. It can grow to extraordinary complexity, necessitating a sophisticated approach to knowledge visualization, balancing the need for simplicity with the full expressive power of the network. In this paper we expose a tool for the navigation of semantic concepts by the use of a 3D user interface and a semantic approach for information storage and retrieval, that together permit users to share information more effectively, and provide reductions in query formulation and execution. To be effective this new approach must be used, and thus an approach that face the user with relevant resources in reply to a query related to a specific domain of interest is desirable. This motivation bring us to develop a prototype, able to support the user during the query composition and to supply information strictly related to his interests, considering concepts and solution related to the semantic aspects of information retrieval.

2 RELATED WORKS

The issue of visually representing abstract information by 3D is not new. Relevant backgrounds for our work can be found in the field of Information Visualization as well as in best practices techniques adopted by existing solutions for ontology representation. The works described below have been assumed as a starting point in the development of our project.

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OntoRama (OntoRama, 2007) is an ontology browser for RDF models based on a hyperbolic layout of nodes and arcs. As the nodes in the center are distributed on more space than those near to the circumference, they are visualized with a higher level of detail, while maintaining a reasonable overview of the peripheral nodes. In addition to this pseudo-3D space, OntoRama also introduces the idea of cloned nodes in order to reduce the number of crossed arcs and enhance the readability. The duplicate nodes are displayed using an ad-hoc color in order to avoid confusion. Unfortunately, this application does not support editing and can only manage RDF data.

Another interesting work is the OntoViz (OntoViz, 2007) plug-in displays an ontology as a graph by exploiting an open source library optimized for graph visualization (Gansner & North, 1999). Intuitively, classes and instances are represented as nodes, while relations are visualized as oriented arcs. Both nodes and arcs are labelled and displaced in a way that minimizes overlapping, but not the size of the graph. Therefore, the navigation of the graph, enhanced only by magnification and panning tools, does not provide a good overall view of the ontology, as the graphical elements easily become indistinguishable. OntoViz supports visualization of several disconnected graphs at once. The users can select a set of classes or instances to visualize. OntoViz generates graphs that are static and non-interactive which makes it less suitable for the visualization of large ontologies.

TGViz (TGVizTab, 2007), similarly to OntoViz, visualizes Protege (Protege, 2007) ontologies as graphs. In this case however, the displacement of nodes and arcs is computed using the spring layout algorithm implemented in the Java TouchGraph library (TouchGraph, 2007).

3 PROVIDING SEMANTIC RELATION TO WEB BASED KNOWLEDGE

Providing traditional Web searching with semantic features is an application of the Semantic Web, based on an explicit representation of semantics about web resources and real world object. It is aimed to improve both the proportion of relevant material actually retrieved and the proportion of retrieved material that is actually relevant. Recently, research on information systems has increasingly focused on how to effectively manage and share data in a such heterogeneous and distributed environment. In particular, the investigation of the Semantic Web as an extension of the actual World Wide Web, is aimed to make the Web content machine understandable, allowing agents and applications to access a variety of heterogeneous resources (Dolog & W.Nejdl 2007).

It has been proposed to deal with problems such as information overload and info-smog that are responsible for the “lost on the net” effect and make the web content inaccessible Our approach is to index and retrieve information both in a generic and in a specific context whether documents can be mapped or not on ontologies, vocabularies and thesauri. To achieve this goal, we perform a semantic analysis process on structured and unstructured parts of documents. The unstructured parts need a linguistic analysis and a semantic interpretation performed by means of Natural Language Processing (NLP) techniques, while the structured parts need a specific parser.

3.1 Semantic Analysis Process

A semantic analysis process will be carried out on the transition from the old style of serving the web-data visualization to the new style of providing the 3D graphical user interface. Firstly, we increase the semantic net of WordNet (WordNet, 2007), a lexical dictionary for the English language that groups nouns, verbs, adjectives and adverbs into synonyms sets, called synsets, linked by relations, such as meronymy, synonymy or hyperonymy/hyponymy, identifying valid and well-founded conceptual relations and links contained in documents in order to build a data structure, composed by concepts and correlation between concepts and information, to overlay the result set returned from the search engine. At the same time we realized the importance of being able to access a multidisciplinary structure of documents, evaluating several solutions like language specific thesaurus or on-line encyclopedia. To achieve this goal we choose a multidisciplinary, multilingual, web-based, free content document encyclopaedia, such as Wikipedia (Wikipedia, 2007), that contains about 1.900.000 encyclopedic information. We used the great amount of documents included in Wikipedia to extract new knowledge and to define a new semantic net enriching WordNet. We added with new terms, new associative relations and their classification, as emphasized in (Harabagiu et al., 1999) where authors identify several other weaknesses in the WordNet semantic net constitution. In fact it contains about 115.000 word "senses", that means few number of connections between words related by topics, not enough respect to the web language dictionary. A conceptual map built using Wikipedia pages allows a user to associate a concept to other ones enriched with some relations that an author points out. The use of Wikipedia guarantees, with reasonable certainty, that such conceptual connection is valid because it is produced by someone who, at least theoretically, has the skills or the experience to justify it. Moreover, the rules and the reviewers controls set up guarantee reliability and objectivity.

4 INTEGRATING 3D INFORMATION VISUALIZATION INTO SEMANTIC NET TECHNOLOGIES

One of the critical issue in our research was to improve the user experience during the phases of searching and extracting of the concepts. We investigate new paradigm and model of UI, specially deepening the study of 3D visualization. Although the exposition of semantic networks into a 2D map presentation can provide reasonably good results in some cases, it is missing some important features to make a real difference and provide satisfactory results. Usually a user is presented with a flat panel, limited in size, where information may be presented in a form of color patches, sometimes textured, with different shapes which can be distinguished when the number of objects presented is low. The user interaction is limited to selecting a point in the panel. What we neededed was to exceeds the capabilities of traditional interaction devices and two-dimensional displays, allowing the user to change the point of view, improving the perception and the understanding of contents (Biström et al. 2005). Our goal was to traverse the net via concept list views, via their relations, or by retracing the user's history. The tool we developed, allows to browse Web resources by means of the map of concept. Formulating the query through the search engine, the user can move through the SemanticNet and extract the concepts which really interest him, limiting the search field and obtaining a more specific result. In a 3D space, a user can easily understand the meaning of an object, simply rotating, shifting, and moving it (Cellary et al., 2004). Each node represented in the 3D view is a concept and arcs are used to showed in order to represents the different kinds of relations between the concepts. If the representation is suitable for the search context, the objects are easy to explore, and the related information are learned faster and better (Wiza et al, 2004).

4.1 Building The Semantic Net

In order to build the SemanticNet, we need to condider terms and their classification. The reason is that varied mental association of places, events, persons and things depend on the cultural backgrounds of the users' personal history. In fact, the ability to associate a concept to another is different from person to person. The SemanticNet is definitely not exhaustive but it is limited by the dictionary of WordNet, by the contents included in Wikipedia and by the accuracy of the information given by the system. Starting from the information contained in Wikipedia about a term of WordNet, the system is capable of enriching the SemanticNet by adding new nodes, links and attributes, such as IS-A or PART-OF relations. Moreover, the system is able to classify automatically the textual contents of web resources, indexed through the Classifier, a module that uses WordNet Domains (Magnini et al., 2002) and (Magnini et al., 2004), and applies a density function, based on the synonyms and hypernyms frequency (Scott, 1998) and the computation of the number of synsets related to each term of the document. In this way, the system is able to retrieve the most frequently used "senses" by extracting the synonyms relations given by the use of similar terms in the document sentences.

Through the categorization of the document itself it can associate the term the most correct meaning and can assign a weight to each category related to the content. In fact, each term in WordNet has more than one meaning each corresponding to a Wikipedia page. We therefore need to extract the specific meaning described in the Wikipedia page content, in order to build a conceptual map where the nodes are the "senses" (synset of WordNet or term+category) and the links are given both by the WordNet semantical-linguistic relations and by the conceptual associations built by the Wikipedia authors. To achieve this goal, the system performs a syntactic and a semantic disambiguation, as better described by Angioni, Demontis and Tuveri (2007), of the textual content of the Wikipedia page and extracts its meaning associating it to a node corresponding to the specific "sense" of a term in WordNet (synset) or, if it does not exists in

WordNet, adding to the SemanticNet a new node (term + category).

5 THE DISPLAYABLE DATA STRUCTURE

As described before, we have enriched the WordNet semantic net with new terms extracted from approximately 60.000 Wikipedia articles corresponding to WordNet terms. Through the classification of the content of Wikipedia pages ,the system assigns them a synset ID of WordNet, if it exists. By analyzing the content of the Wikipedia pages, a new kind of relation named “COMMONSENSE” is defined, that delineates the SemanticNet with the semantic relations “IS-A” and “PART-OF” given by WordNet. The COMMONSENSE relation is a connection between a term and the links defined by the author of the related Wikipedia page. These relations are important each time the system give back results to a query. Results provide the concepts referred in WordNet or in the Wikipedia derived conceptual map. The concept map is constituted by 25010 nodes each corresponding to a “sense” of WordNet and related to a page of Wikipedia. Starting from these nodes, 371281 relations were extracted, part of which are also included in WordNet, but in the most case they are new relations extracted from Wikipedia. Terms not contained in WordNet and in Wikipedia are new nodes of the augmented semantic net. Terms which meanings are different in Wikipedia in respect with the meaning existing in WordNet will be added as new nodes in the SemanticNet but they will not have a synset ID given by WordNet.

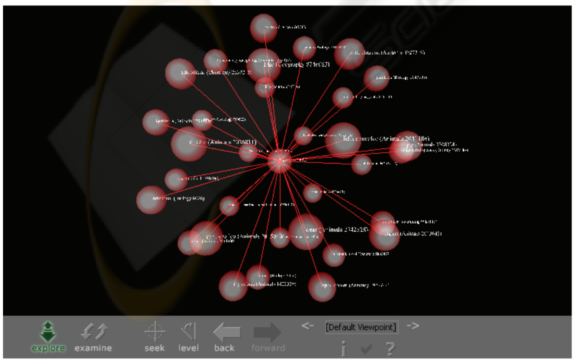

Figure 1: A view of the 3D UI with COMMONSENSE relation.

In Figure 1 a portion of the SemanticNet is described, starting from the node tiger. The Wikipedia text related to the term is analyzed and classified under the category Animals. In this way the system is able to exclude one of the two senses included in WordNet, the one having the meaning related with person, and to take into consideration only the sense related with animal.

So, all the new relations extracted from the page itself as well as the relation included in WordNet can be associated to this specific node by the system.

6 ARCHITECTURE OF THE 3D USER INTERFACE

A major motivation for keeping 3D GUIs for displaying search results simple is to keep them user-friendly. In general the 3D UIs for displaying virtual worlds need more immersive and ad hoc hardware interfaces, anyway in our case one of the essential requirements was to guarantee a good usability by concrete representations and simplicity (Houston, 2002).

As a consequence we need to keep the user into a Web context, and allowing her/him to manage interactive 3D contents within the Web browser.

Recently Web sites that include 3D content, i.e. Web sites where users navigate and interact (at least partially) through a 3D graphical interface, are increasingly employed in different domains, such as tutoring and training, tourism, e-commerce and scientific visualization However, while a substantial body of literature and software tools is available about making 2D Web sites adaptive, very little has been published on the problem of personalizing 3D Web content and interaction.

6.1 Adaptive Manipulation Of 3D Web Content

To identify the best approach to achieve the task of adaptive manipulation of 3D Web content, we have explored several 3D Web technology. The study has been limited only to W3C languages able to describe virtual worlds, we have deliberately choose to do not consider java applets, flash interactive movies, and other technologies that can be integrated into web pages to view 3D contents. In particular at the begining we have evaluated and discarded VRML (VRML), 3DML (3DML tutorial). The reason to set aside these languages is that they require plug-in modules with a partial support to their specifications.

We also considered SVG (SVG) as another way to avoid 3D interactive contents, specially because SVG engines are natively supported by the most common Web browsers. Unfortunately this language is not dedicated to 3D graphics and it needs ad-hoc extensions to process 3D contents, from our point of view it looks too restrictive because makes the all process too trivial and do not guarranties a good level of interactivity. At the end of the analisy we finally choose the X3D (eXtensible 3D) language (Web 3D Consortium, 2007) This choice has been driven by its features, specially because it is is the ISO open standard for 3D content delivery on the web supported by a large community of users.

Conceptually, the semantics of X3D describe an abstract functional behaviour of time-based, interactive 3D, multimedia information and do not at all specify a specific software or hardware setup. The key difference with the other languages is inherent in the X3D runtime environment, in particular the scene graph, which is a directed, acyclic graph containing the objects represented as nodes and object relationships in the 3D world. The basic structure of X3D documents is very similar to any other XML document. All elements are nested within the X3D tag including the scene graph tag.

6.2 Implementation

The user interface that we have developed is a software module used according to the user preferences and the current user context that provides an interactive scene defined by a X3D document that represent the selected portion of SemanticNet. Depending on the search context it provides a three-dimensional view that guarantees a better usability in terms of information navigation, and it could also provide different layouts for different cases. When the user provides a query expressed in Natural Language, the system analyse it, and returns a set of results containing the main categories and the more representative synset found

If the results don't fit with the the user need, he can decide to reformulate a new query using the SemanticNet in order to enrich the query with new terms related or semantically near to the original query

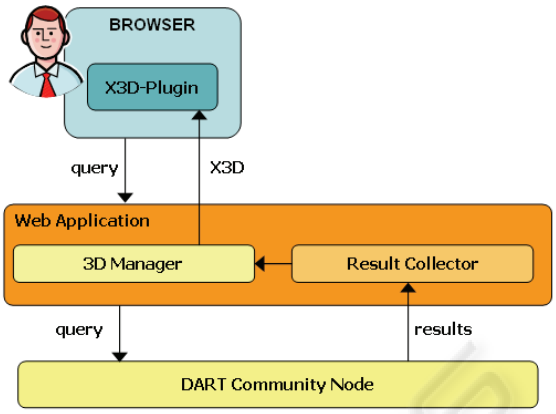

Figure 2: Software Architecture.

The module parts are:

- Web Application – it is the interface between the SemanticNet and the front-end of the 3DUI. Its tasks are to submit the query originated in the browser to the SemanticNet, to forward results to the ResultCollector, and finally to encapsulate and to send the X3D document to the browser.
- ResultCollector – it has the role to collect the retrieved terms semantically related each other by the means of a concept list. It analize their relations, and provide a suitable description defined by a GraphML file (GraphML Working Group) and (Bonnel, 2005).
- 3D Manager – it receives and parse the GraphML file that describe the interested portion of the SemanticNet within its structural properties including directed, undirected, mixed and hierarchical graphs, starting from the singular node. It also generates on the fly the X3D document that offers an interactive 3D scene with the search results. Subsequently it sends the document to the Web application that makes it available to the user browser.

```
<node id = '52'>
   <data key='synsetID'>2045461</data>
   <data key='term'>tiger</data>
   <data key='desWikiID'>tiger. Tigers (Panthera tigris) are mammals of the Felidae family and one of four "big cats" in the panthera genus..</data>
   <data key='desWNID'>large feline of forests in most of Asia having a tawny coat with black stripes; endangered</data>
   <data key='category'>Animals</data>
   <port name='common_sense' />
   <port name='is_a' />
   <port name='part_of' />
</node>
<node id = '5589'>
   <data key='synsetID'>2041186</data>
   <data key='term'>cougar</data>
   <data key='desWikiID'>cougar. The puma (Puma concolor since 1993, previously Felis concolor) is a type of feline (cat)..</data>
   <data key='desWNID'>large American feline resembling a lion</data>
   <data key='category'>Animals</data>
   <port name='common_sense' />
   <port name='is_a' />
   <port name='part_of' />
</node>
<edge id='n032' source='5589' target='52' sourceport='common_sense' targetport='common_sense'>
   <data key='weight'>1</data>
</edge>
```

Figure 3: An example of the GraphML exchange file.

7 CONCLUSIONS

The goal of search engines is increased usage and the common wisdom is that a simpler interface broadens the base of potential users. We have presented a 3D interface for a web search engine that permits the user to decide which other "meanings" add to the original query. We have explored the opportunity to provide a such software infrastructure for the management of semantic knowledge structures in the ambit of the WWW, investigating new interaction models and design principles in order to create a better interactive systems. The tool we developed allow to browse Web resources by means of the map of concept called "SemanticNet" built enriching the WordNet semantic net with new nodes, links and attributes. The importance of integrating 3D Information Visualization into semantic network technologies is that 3D may support semantic search process providing functionalities to make the information more accessible and improving their usability. The future works are focused on improvements in the interface selection method and development of new interfaces for the SemanticNet. It is expected that the interface selection algorithm may be improved by registration of user interactions, such as preferred visualization interfaces and options selected in particular interfaces.

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