SUPPORTING KNOWLEDGE SHARING WITHIN AN ORGANISATION

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Abstract

This paper discusses the design, architecture, and use of interactive visualisations and presents a system that allows the creation of a virtual world representing a concept space to assist knowledge sharing. Knowledge sharing is based on building and manipulation of the concept space, which can be individually or collaboratively built and refined. The proposed system uses a 3D interactive visualisation interface to support user exploration and enhancement of the concept space. The concept space is somewhat a 3D semantic map, allowing users to define concepts by listing associated keywords.

The system design is briefly described in order to argue how visualisation, in particular 3D interactive visualisation, can be used for knowledge sharing support and group interaction. Applications of this system include information retrieval and indexing, and group knowledge sharing such as in educational settings. The paper ends by introducing how this system can be applied to support knowledge sharing activities within an organisation.

Keywords virtual environments applications, visualisation, knowledge sharing, co-operation and collaboration interfaces.

1 Introduction

When dealing with representations it is rather obvious that different representations can enhance the understanding level of a particular problem [Tufte, 1990]. The form of representation makes a dramatic difference in the ease of the task and its proper choice depends upon the knowledge, system, and the method being applied to the problem [Norman, 1993].

This work aims to prove how computer mediated 3D visual representations can be useful in helping the understanding and communication between individuals by sharing conceptual information as proposed by Benedikt [Benedikt, 1992]. Application areas include sharing of thesaurus, information maps, complex domain information, and contexts; application domains include information retrieval and visualisation from large data sets (e.g. the Web), and sharing of context information about educational domains.

Visualisation offers advantages and opportunities when we deal with complex data sets, ill-structured and dynamic information, the kind of settings that characterise actual systems where we face understanding and learning problems, info-glut, and information overload [Forrester, 1987].

Norman proposes that external representations, especially ones that can be part of a workspace shared with others, require some sort of constructed device to support them: an artefact

[Norman, 1993]. He also adds that the metarepresentations of thoughts and concepts are the essence of reflection and of higher-order thought. It is through metarepresentations that new knowledge is generated, finding consistencies and patterns in the representations that could not readily be noticed in the world [Norman, 1993].

For our purposes, the generation of extended semantic map visualisations can be of interest. The conceptual space as referred by [Hutchins, 1995] will serve as initial starting point for the present work. The research can be stated as the use of 3D facilities to improve knowledge sharing by proposing a representation to be used as a collective reflective artefact [Li-Jen and Gaines, 1998].

The proposed interface tries to remove the computer as an object of perception, allowing the user to interact directly with the generated environment as discussed by [Hubbold et al., 1995].

1.1 The use of Semantic Maps

Semantic Maps are a strategy for graphically representing concepts. Semantic Maps portray the schematic relations that compose a concept. It assumes that there are multiple relations between a concept and the knowledge that is associated with the concept. Thus, for any concept there are at least these types of associations:

2 class: the order of things the concept falls into;

3 property: the attributes that define the concept;

4 example: exemplars of the concept.

Semantic Maps are used also to identify techniques which describes a variety of strategies designed to show how key words or concepts are related to one another through graphic representations [McAleese, 1998].

A general procedure to develop a Semantic Map is by having a group discussion. In a situation like this, it is almost inevitable that the three types of concept association's class, property and example will emerge.

The major purpose of a Semantic Map is to allow students organise their prior knowledge into formal relations and thus provide to themselves a basis for understanding what they are about to read and study. Comprehension can be thought of as the elaboration and refinement of prior knowledge. Semantic Maps provide a graphic structure of knowledge to be used as the basis for organising new ideas as they are understood [McAleese, 1998].

One of the first to propose the development of a Semantic Map procedure was [Hanf, 1971]. The procedure was designed to improve the teaching of study skills. However, the notion of Semantic Maps is older and based on [Ausubel, 1963] who claimed that background information was a necessary prerequisite to the addition of new concepts and vocabulary.

Ausubel defends that when individuals are presented with new concepts, these concepts will not be explicitly understood until they are linked in a meaningful way to pre-existing concepts [Ausubel, 1963]. Similarly, reading theorists have likened the process of reading comprehension to relate the new and the unknown [Pearson and Johnson, 1978].

Gathering the several uses of Semantic Maps is possible to list them as:

- a technique for increasing vocabulary and improving reading comprehension;
- a means of improving the teaching of study skills;
- a framework for identifying the structural organisation of texts;

- a means of teaching critical thinking skills;
- an assessment technique.

This paper is organised as follows: section 2 introduces “concept spaces” and how they are built; section 3 presents the visualisation of concept spaces; section 4 presents criteria spaces, that is, how we can work with concept spaces and visualise them; section 5 shows how a data source can be integrated with the concept spaces, and section 6 presents potential applications and section 7 our concluding remarks.

2 Concept spaces

Our system uses a 3D visualisation based on a structured description of a domain based in concepts and weighted keywords — defined here as a concept space. For our purposes, keywords associated with a concept define that concept. Figure 1 presents two concepts and their respective keywords; this example shows part of a concept space about the Human Computer Interface (HCI) domain.

Computer	**Interface**
Order, 0.67	order, 0.34
Technology, 0.7	operation, 0.76
Automatic, 0.67	human, 0.8
Processing, 0.8	computer, 0.56
Structure, 0.7	

Figure 1 - Part of a concept space for the HCI domain

In the above figure two concepts are presented: Computer and Interface. For each one, a group of keywords is listed. Keywords like order exist on both concepts but with different weights, as chosen by the person who created this concept space.

Keyword weights are values between zero and one, and give the degree of membership of a given keyword to the concept. Notice that the sum of all the keyword ratings do not have to be equal to 1 for a given concept. This means that keyword weights are independent and similar to fuzzy sets.

A relation between any two concepts can be established when one or more keywords exist in both concepts. Its also possible to compute a degree of similarity between two concepts by taking into account the existing weights in both occurrences of each keyword. The algorithm to compute a relation between two concepts uses keyword names and ratings and returns a value between zero and one, being the value zero a non similarity result; a value of one means total similarity, although not equality. A relation between two concepts, one being defined by a subset of the keywords of the other has a value of one, although the two concepts are not the same.

3 Visualisation of concept spaces

Based on this structure, the visualisation is rendered. Other information can be included attached to this basic structure allowing for a richer subject domain description. An example can be the use of url references to attach html pages to each concept and even to each concept's keyword.

The system allows concept space sharing and supports user proposals for enhancing the structure. In order to support this functionally, a user with proper rights can propose new concepts and keywords, propose new ratings for existing concept keywords, and propose the elimination of existing concepts and keywords from the structure. Each user proposal is voted by all the group members and if accepted included in the structure. The system uses a voting tool to support the structure enhancement.

Each concept is defined by a number of keywords that characterise it. The exact number of keywords varies for each concept and can always be modified later. Each keyword consists of a name that can be used for search — composing a query — or defining a particular characteristic and an associated weight. Any user can also later modify a keyword weight by proposing a new value to the user group.

Figure 2 presents a screenshot of the concept space visualisation. Note that each concept is represented using a sphere where colour and size takes into account the keyword group. The size is computed as a function of the number of keywords used to characterise the concept taking into account its ratings. The greater the number of keywords and their ratings, the more important is the concept.

The lines between spheres represent a semantic distance, which is colour coded. The semantic distance between two concepts is calculated by a function that uses the ratings of the keywords common to both concepts. With proper controls, a user can navigate in the 3D world by rotating, translating and zooming.

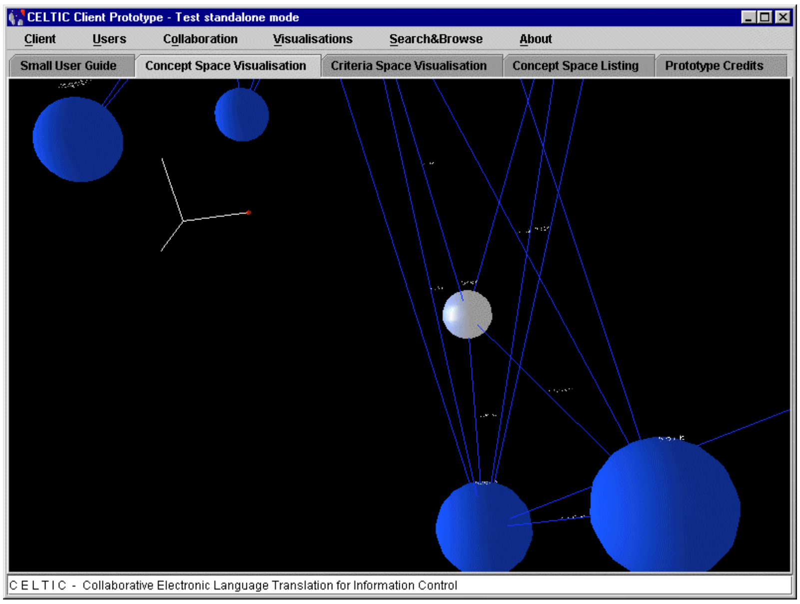

Figure 2 - A concept space visualisation

The semantic distance between two concepts is computed as a degree of keyword similarity taking into account keyword weight and the colour used means four levels of similarity:

The first level uses the white colour for a similarity degree of up to 25%; white blue is used for values between 25 and 50%; blue is used for values between 50% and 75%; and red is used for values between 75% and 100%. A label attached to the link gives the precise value for each case. By default, the concept space visualisation displays only the blue and red links. The user has the option to visualise all the relations between concepts.

As soon as the group of users agrees on a common understanding of the concept space, they can start exploring it. In the next section we explain of users can extract useful information from a concept space by projecting it over specified criteria.

4 Working with concept spaces

The system allows each user to interact with the shared visualisation — concept space — and produce a second visualisation from it. The second visualisation is derived from the initial concept space and supports user exploration and organisation of retrieval, search and browse tactics.

The second visualisation is based on the spatial rearrangement of the existing concepts. The user can introduce up to three criteria to project the concepts in a Cartesian space. Those criteria must be chosen from the existing keyword collection in the concept space. The second visualisation is referred as the criteria space. As the criteria space is a 3D space, the user can enter three criteria to determine a spatial position for each concept based on its keywords' weight values.

Thus, the use of the criteria space allows the user to analyse the concept space from its own perspective and information needs, letting the user visualise different combinations of keywords (criteria) for grouping existing concepts.

4.1 The criteria space

The spatial position of each concept in the criteria space is computed by comparing the criteria with existing keywords on the concept and using keyword weight as a coordinate value for the criteria. If the criteria do not exist for a particular concept, a coordinate value of –1 is given to the concept for the corresponding criteria dimension. This negative value places the concept in a different position within the dimension used to represent the criteria.

Figure 3 shows a criteria space example with several concepts (spheres) placed along the three axes.

The resulting criteria space produces a visualisation of eight possible quadrants resulting from the three criteria combination of three dimensions. In the criteria space visualisation, each sphere is represented with the same size but remains with original colours, used in the concept space visualisation.

The colour coding for the concepts denotes each concept's relevance within the concept space. Three levels are defined, been the most important concepts coded in red; the base concepts (strong related with the concept space context) are blue and others are coded in white blue (see both figure 2 and 3).

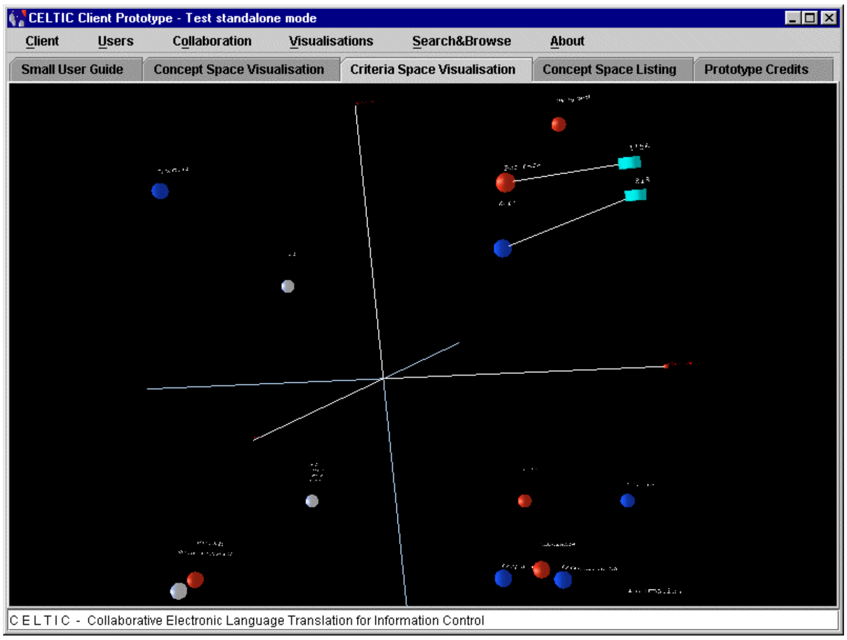

Figure 3 - The criteria space

4.2 Services for collaboration

The services for collaboration includes a voting tool to collaboratively decide which proposals to enhance the structure are accepted (add or delete concepts and keywords and alter keywords weights). Another collaborative tool is a chat system that supports user discussion and provides a synchronous communication facility complementing the concept space visualisation. An annotation facility allows the adding of additional information to each concept in the structure. The system also provides basic user awareness support by list system users and current connected user information. These services allow a basic set for collaboration as discussed by [Lea et al., 1997].

In the next section we show how the system can be integrated with a data source, and the operations which are allowed on it.

5 Linking with a data source

The criteria space can be integrated with a data source, as long as one requirement is fulfilled: we must be able to perform textual searching over the data source. The textual search is performed with keywords from the concept space, although other search techniques, such as metadata searching or catalogue searching could be used.

The results are used to generate another information visualisation that is used to compare against the first quadrant concepts of the criteria space. The first quadrant contains all the concepts that satisfy the three criteria (see figure 4).

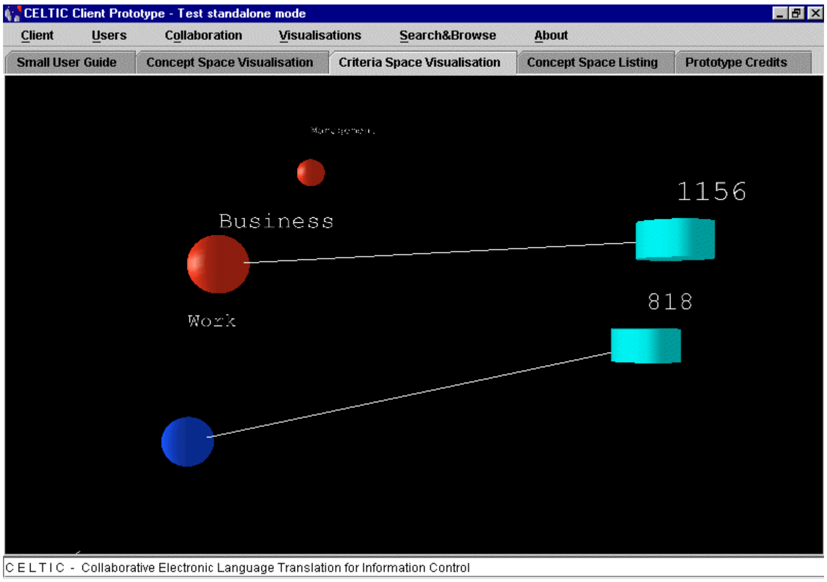

Figure 4 - The information visualisation

The resulting visualisation provides information about the data source related with each concept from the first quadrant; data sources are displayed as a green cylinder, and linked to the corresponding concept.

Each cylinder represents the data source, with a label giving the number of occurrences of the concept's keywords in the data source. The position also indicates the keyword occurrences in the data source given the total number of occurrences for all combined existing keywords for a concept. It thus provides information to place the cylinder (data source) as the one that was used to place the sphere.

Having an information visualisation [Card et al., 1999] within the criteria space lead us to the possible integration between the structured knowledge sharing that has been enhanced and built by a group of people, and a given data source, such as the World Wide Web or a library.

This is made possible by populating the criteria space with metadata from the data source [Baeza-Yates and Ribeiro-Neto, 1999]. The co-existence of this information allows for the analysis of a given data source, for example if it can potentially have relevant information concerning the subject represented by the structure for knowledge sharing and how well it fits the context represented in the concept space.

6 System applications

A number of applications can be devised for the proposed 3D interactive visualisation. The use of virtual environments based information representation provide the opportunity to develop cooperation and collaboration interfaces [Chalmers and Chitson, 1992].

The proposal we present can be potentially used in several applications, where knowledge about the meaning of concepts, objects and situations, need to be shared. Among these applications are content management, workflow systems and knowledge management [Wexelblat, 1991].

The proposed system provides a semantic layer to access digital information stored in a computer or computer network. It does that by translating a network of concepts that describes a given context to a structured string query to access-related information and content. It also integrate the sharing of such a concept network with the possibility to each user takes advantage of the shared context to interactively create its own queries.

However, the current work focuses on the interface by proposing a visualisation to be shared among a group of users. A simple demonstration is proposed to show how the proposed structure can be integrated with current search engines, available within an organisation Intranet.

7 Conclusion

The proposed 3D interactive visualisation provides the means for integration between the services needed to allow collaboration for enhancing the structure, and allows for group interaction. It also provides a visual interface for semantic access to information as an independent layer regarding a data source. Any data source can be used, and explored using the concept space and the criteria space (the second visualisation, based on user chosen keywords).

By introducing the criteria space visualisation we allow the users' exploration of the shared concept space by rearranging its concepts based on given criteria. It also provides a context to support reasoning and even decision processes based on shared knowledge.

Additionally the criteria space visualisation allows integration of the structure for knowledge sharing with data source information. In ill-structured or complex domains, this visualisation offers the possibility of discovering relations between given concepts, which define, in a sense, an information context, which can be used for several applications within an organisation such as content management, workflow systems and knowledge management.

Para que o trabalho seja publicado nas actas da conferência, pelo menos um dos autores deverá efectuar a inscrição na conferência.

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