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Subject Explorer 3D: a Virtual Reality Collection Browsing and Searching Tool

Abstract: Controlled vocabulary is known to help searchers and Semantic Web ontologies are one of its latest incarnations. Unfortunately, many searchers are unaware of this useful organization of information. An interactive 3D fly-through search and browsing prototype was developed and is proposed as potential solution to enhance navigation.

Résumé : Le vocabulaire contrôlé est reconnu pour aider les chercheurs et les ontologies du web sémantique en sont la dernière incarnation. Malheureusement, nombre de chercheurs ne connaissent pas cet utile outil d'organisation de l'information. Un prototype interactif de recherche et de navigation en 3D a été développé et est proposé comme solution pour rehausser la navigation.

1. Context and Problem

All libraries, many corporations and the semantic Web organize information using forms of controlled vocabulary (CV); however, many searchers are unaware of CV in part because of inadequate subject browsing interfaces (Bates 2003; Drabenstott 1991). This is unfortunate because the value of controlled subject vocabulary has been demonstrated (Bates 2003; Lancaster 1986), and information professionals explicitly use CV because they know it yields more relevant results (Chen *et al.* 1998, 597).

The most widely used and extensive example of a CV scheme is the Library of Congress Subject Headings (LCSH) (Chan *et al.* 2007; Taylor *et al.* 2006); furthermore, the SKOS[1] initiative aims to translate existing ontology knowledge such as LCSH into a vocabulary compatible with the Semantic Web. LCSH is thus a comprehensive case of real world CV usage which may eventually be partly transferred to the Semantic web.
Using LCSH as a test case, this research aims to facilitate untrained user's access to CV and the information it contains. The resulting prototype is based on techniques from the field of information visualization (IV) and aspires to be an intuitive and appealing subject browsing *and* information retrieval tool.

2. Framework

An ideal information retrieval system should fully integrate browsing with searching and allow users to iteratively switch effortlessly between both types of search tactics (Lin 1997, 41; Marchionini 1995; Pejtersen 1988; Shneiderman *et al.* 2000, 62). Keyword searching is an adequate tool for well defined needs with recognizable answers (e.g., What is the capital of Norway?); alternatively, browsing (Chen *et al.* 1998; Heo 2000; Lin 1997; Marchionini 1987; McAleese 1989) takes place when the need is broad and/or complex and the potential answer is a collection of related and supporting information (e.g., How can physical exercise effect the quality of life of cancer patients?).
An explorative browsing process may be well supported by direct manipulation visual interface metaphors which are preferred to text-only interfaces and easier to learn for novice users (Carroll *et al.* 1982; Hearst 1999, 282; Shneiderman 2003, 364). Interactive

IV interfaces (Card *et al.* 1999) offer techniques to *complement* text-only search interfaces with direct manipulation visual metaphors of information spaces. The primary aim of IV is to visually reveal patterns or identify characteristic features in large data sets (Bederson *et al.* 2003, ix).
This research aims to facilitate information exploration and retrieval using interactive IV to reveal two main patterns found in CV ontologies: 1) power law distribution of assignments, and 2) hierarchical structure of broad to specific subjects. Like many collections (e.g., Web page links), CV assignments follow a power law pattern; few subjects contain large groups of items while most subjects contain few items (Bates 2003; Julien *et al.* 2009). Bates (2003) goes on to suggest that it is likely that most large groups "are not only large themselves but are also of interest to disproportionate numbers of...users" and providing quick access to a "few large families may satisfy many users quickly" (40). CV such as LCSH is also partly a hierarchical pattern of broad to narrow terms which explicitly organizes information collections. Hierarchies are ubiquitous and often large which makes these structures good candidates for information visualization (Chen 2004, 90; van Ham *et al.* 2003, 31).

Is this ideal information retrieval system viable, i.e., is it possible to visually reveal these two patterns (namely, power law assignments and subject hierarchy) within an interactive browsing and searching interface using known IV techniques? What is a suitable information metaphor and how would users browse and search through the CV subject headings and the bibliographic records?

3. Proposed solution: Subject Explorer 3D (SE-3D)

A useful subject hierarchy is too large to be visually represented; however, it can be simplified by pruning most subject classes which are assigned to very few items. Sacrificing some information in order to gain simplicity is sometimes justified (Moya-Anegón *et al.* 2004, 136; Small 2000) since "what is sought in designs for the display of information is the clear portrayal of complexity" (Tufte 1983, 191). The result is a visual representation of a subject hierarchy which clearly reveals the few subjects which are assigned to the vast majority of the collection.

Large information structures may be well represented and pleasantly navigated in a 3D environment (see review in Teyseyre *et al.* 2009). It has been suggested that a 3D hierarchy can make more efficient use of screen space (Robertson *et al.* 1991), and is better suited to convey hierarchical relationships between levels (Bladh *et al.* 2004). There are few evaluations studies of IV for information retrieval applications (see review by Julien *et al.* 2008) and even fewer with 3D IV interfaces (see review by Hearst 2009, section 10.10). These scarce reports suggest lower performance with 3D visualizations (see review from Katifori *et al.* (2007)); nevertheless, experimental results suggest 3D is preferred by users (Levy *et al.* 1996; Perez *et al.* 2004; Smallman *et al.* 2001).

The SE-3D Prototype

A virtual reality subject browsing and information retrieval prototype was built based on the collection housed in the McGill Schulich Library of Science and Engineering (over 130,000 bibliographic records) and subject authority file (over 280,000 records). An automatic process was developed to port the raw MaRC data to a relational database, extract the hierarchical structure from the authority records, and prune it based on the distribution of subject assignments in the bibliographic records.
The resulting 3D fly-through search and browsing prototype allows users to explore the LCSH subject hierarchy and its assigned documents by travelling up and down the

hierarchy of broad to narrow subjects. Integrated with keyword searching, users are able to visually inspect subject headings written on labels hovering hierarchy branches (see Figure 1).

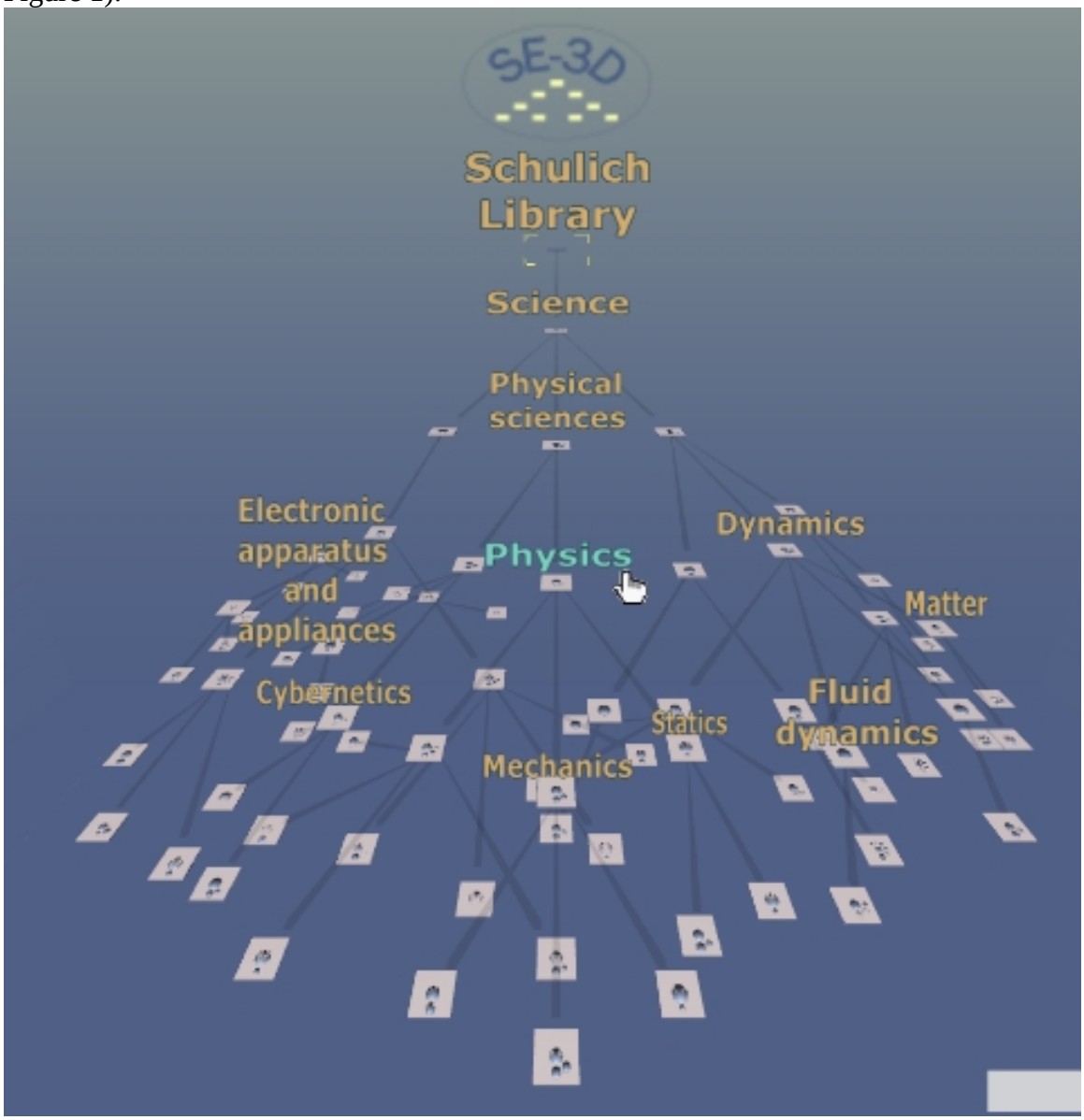

Figure 1. Initial view of Subject Explorer 3D. The user can browse LCSH terms by point-to-fly navigation and keyword search is always available. By visual selection the searcher can interactively explore the collection down to the most specific subjects and their content (see Figure 2).

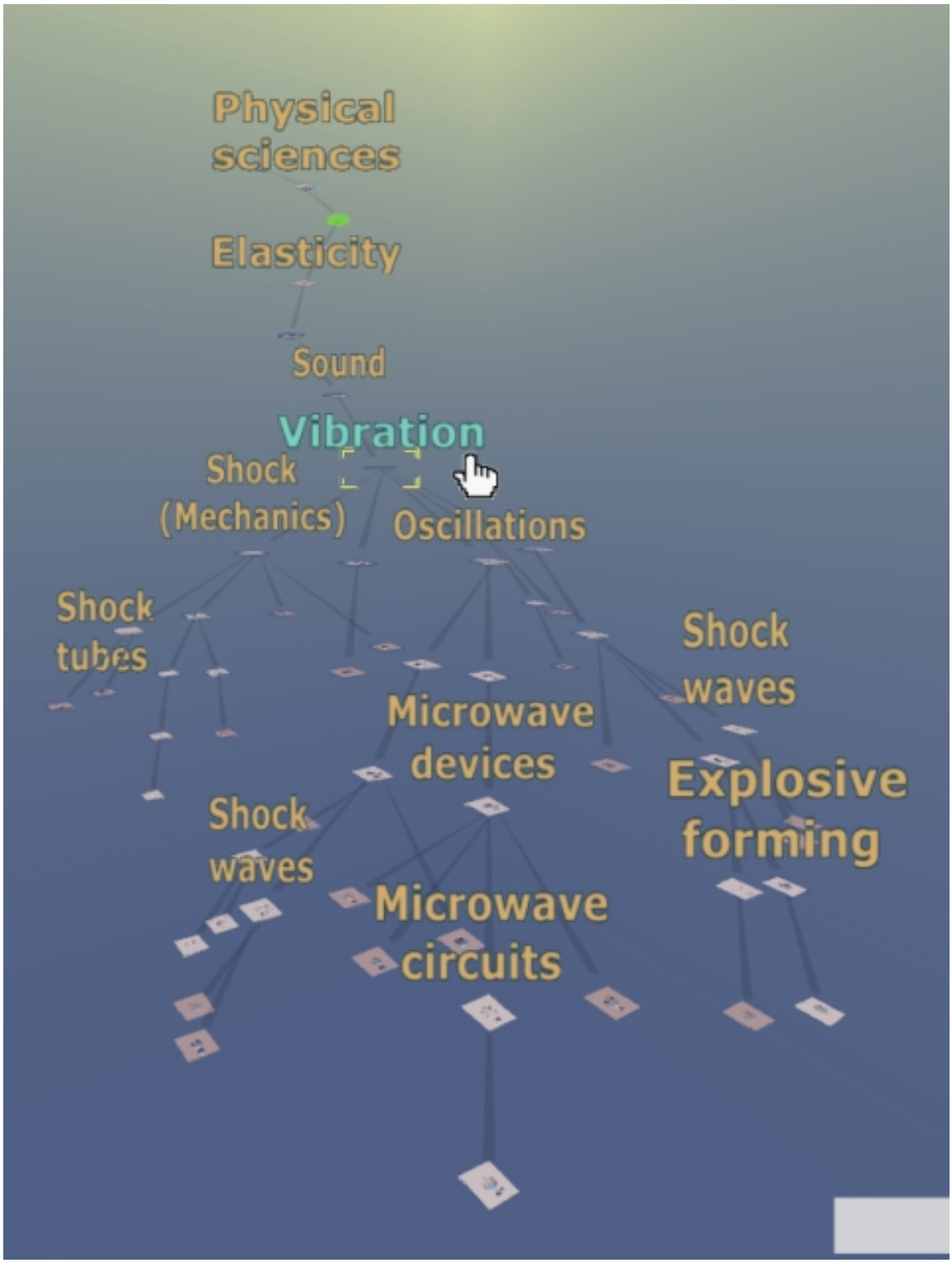

Figure 2. SE-3D searcher has drilled down to the most specific subjects of the subject hierarchy. Some of the squares have a slightly darker tint to suggest that no further subdivisions are available.

At any point in time the user can perform a keyword search and inspect individual information items (see Figure 3).

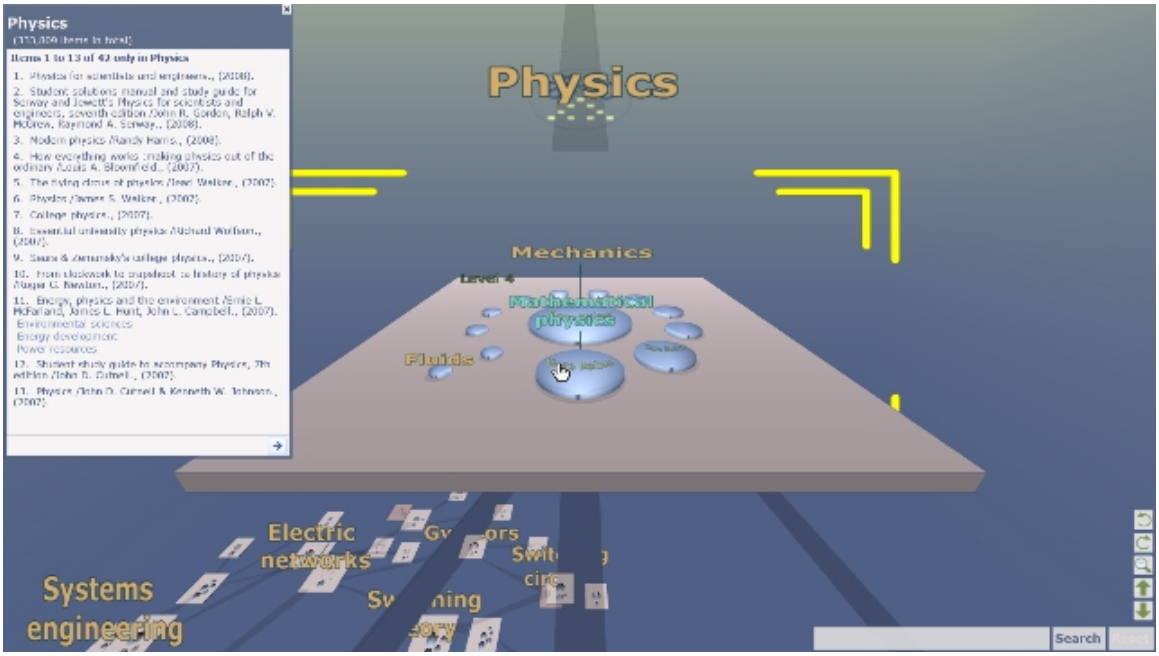

Figure 3. Users of SE-3D can always perform a keyword search and inspect individual information items. Circular areas are sized to suggest the relative number of documents covering the topic.

4. Previous Research

There have been a few attempts at visual interfaces for the MeSH[2] CV. Contrary to LCSH, the MeSH[3] taxonomy is easier to visually represent because it is highly structured and strictly covers the medical field. For example, PNASLINK (White et al. 2004) uses MeSH term co-occurrence for an IV information retrieval system but, unlike SE-3D, searchers must first specify an initial MeSH subject term. MeSHBrowse (Korn *et al.* 1995) and Visual MeSH (Lin 1999) provide 2D representations which allow users to interactively browse a subset of the MeSH relations but, unlike SE-3D, these do not provide content searching capabilities. Cat-a-Cone (Hearst *et al.* 1997) is an early limited 3D interface of a MeSH organized collection and is, as far as we know, the only interactive IV prototype with some kind of integrated CV structure browsing and keyword searching. The technique described by Moya-Anegon *et al.* (2004) represents subject terms but the static 2D knowledge domain maps represent author co-citation relationships between subjects.

We've found no other studies attempting to visually represent the complex LCSH hierarchy, either in 2 or 3 dimensions. SE-3D is also one of few complete information retrieval tool which tightly integrates traditional keyword searching of the collection and direct manipulation subject browsing.

5. Insights Revealed and Conclusion

The design and development of the SE-3D prototype has so far revealed that 1) LCSH broad to narrow terms can be transformed into a usable visual hierarchy which 2) explicitly represents less than 9% of the subject headings assigned to the collection 3) while offering the vast majority of bibliographic items (over 93%) one or more times. The design of SE-3D has also generated novel types of human-information interaction techniques through tight integration of individual information items and keyword searching results within the subject hierarchy visual metaphor. This research shows that it is possible to use existing value offered by complex controlled subject vocabulary

assignments in current collections all over the world and for the future Semantic Web. Finally, this ongoing research takes the suggestion from human-centered research and delivers more "concrete design solutions" (Saracevic 1999, 1057) to information retrieval system problems. Future direction include usability testing and comparison with text-only information retrieval systems in terms of performance and affective reactions.

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[1] see http://www.w3.org/2004/02/skos/
[2] Medical Subject Headings
[3] Medical Subject Headings