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**Navigating the virtual library:
A 3D browsing interface for
information retrieval**

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Navigating the virtual library: A 3D browsing interface for information retrieval

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Abstract: An interface is described for graphically navigating a large collection of documents, as in a library. Its design is based on the metaphor of traversing a landscape. Documents are depicted as buildings, clustered to form 'towns'. A network of 'roads' connects these towns according to the classification hierarchy of the document set. A three-dimensional scene rendering technique allows the user to view this landscape from different perspectives, and at different levels of detail. At one level, the appearance of the buildings provides information like document size and age, at a glance. At higher levels, we provide the user with a visualisation of the structure and extent of the document set that is impossible with a traditional 'shelf' presentation. At all levels, a sense of physical context is maintained, encouraging and supporting browsing.

I. Introduction

The most difficult searches to perform in a conventional Boolean retrieval system are the keyword searches: users generally find it difficult to fine-tune this type of query, and can oscillate between too few (or no) hits and an overwhelming flood of responses (Salton and McGill, 1983).

Two broad types of solutions have been proposed: to automatically or semi-automatically refine a *textual* query, or to provide the user with *graphical* aids for constructing queries and dealing with poor search results. Examples of the former approach include: relevance feedback, in which relevance assessments supplied by the user for previously retrieved documents are used to reformulate the query (Salton 1985); word stemming and term expansion, in which query terms are replaced with their linguistic stems and/or with additional terms from a thesaurus (Salton, Buckley and Fox 1983); and ranked query output, in which the query results are ordered so that the best query-document matches appear first (Noreault 1977).

Graphically based systems for query construction and refinement note that the user's problems may stem from an incomplete understanding of the structure of the document collection, or a lack of prior knowledge of the relative distribution of the

documents over the classification terms. By browsing a graphic structure such as a classification hierarchy or term network, the user can select or negate terms to incrementally enlarge or refine the query. A number of systems have been proposed that utilise this type of interface: Doyle (1961) discusses a graph-based interactive browsing environment; Croft (1983) extends Doyle's term-based graph with vertices and edges representing individual documents and their degrees of similarity to each other; Frei and Jausin (1984) use tree structures to represent both system command menus and document indexing structures; and Godin (1989) and Pedersen (1993) model a collection's conceptual structure with term-document lattices.

It is the latter, graphically based approach that we have chosen to investigate. In this paper, we discuss an interface design that enlarges upon these two-dimensional graphic term displays by making use of the virtual reality paradigm. In response to a query, the user is shown a view of those sections of the physical library containing documents matching the search terms. Documents are depicted as buildings, clustered to form 'towns'. A network of 'roads' connects these towns according to the classification hierarchy of the document set. The landscape can be viewed from different heights: close in, the appearance of the buildings provides information like document size and age at a glance, while from a distance the roadways provide the user with a visualisation of the structure and extent of the document set.

If the user is familiar with the collection organisation or is looking for a particular item, then they can quickly focus on the appropriate portion of the library and retrieve the desired document(s). Users with less precise queries can browse through sections of the classification hierarchy that hold publications matching the search terms, and also examine documents "near" the matched ones.

In the latter case, the interface is supporting a common and efficient search strategy—using a keyword search to locate the desired classification categories, followed by browsing through the books in those categories or adjacent ones (Geller 1983). Indeed, it appears that one of the major

library classification schemes, the Library of Congress system, was designed with this type of search in mind; turn-of-the-century reports from the Librarian of Congress stress that the system was tailored "to the usages in vogue [at the Library], a distinguishing feature of which is the freedom of access to the shelves granted to serious investigators" (US 1916). Clearly, the Library users were originally intended to use catalogue searches mainly to provide appropriate browsing points in the stacks.

There are, however, advantages to browsing a virtual, rather than physical, library. Avoiding tiresome trudges through the stacks to look at widely scattered results is surely the foremost! Other advantages include viewing the documents as clustered solely by content similarity, rather than according to the need to fill out physical shelves or floors; the ability to change perspective by zooming in or away from the documents, giving an impression of the scale and structure of a collection; and the ability to put a document at more than one place in the hierarchy, rather than being bound to the "one book, one spot" restriction of a physical library. The use of scene rendering techniques to display search results allows a virtual library to retain some of the advantageous features of a physical library. Users can quickly scan a set of document surrogates for much of the information that we get from viewing physical documents: an indication of the document's age, length, etc.

The following section describes our interface design, and presents a sample interaction. Section 3 discusses additional areas for research in extending and evaluating this interface.

II. The interface design

FSN (pronounced "fusion"), a three-dimensional file system navigator for Silicon Graphics workstations, was used as a basis for demonstration of the proposed retrieval interface (FSN 1994). We represented each document in our test set as a file, built the classification hierarchy for the documents as a directory/sub-directory hierarchy, and then used FSN to create and navigate the graphic file system/document set. We have proposed adaptations to the FSN display metaphor to meet the demands of document representation (see Section 3), but have not implemented them.

The following discussion illustrates the process of refining a query on the general term "artificial intelligence". As the AI literature is notorious for its wide scatter across a variety of disciplines (Mills 1986), this query gives a good indication of the capacity of the proposed interface to organise search results and facilitate browsing.

2.1 Hierarchical presentation

The initial results of a keyword query are shown in two windows: a small "bird's eye" of the library containing documents matching the query (Figure 1a), and a larger window with a 3D view through which the user navigates to view the retrieval set more closely (Figure 1b).

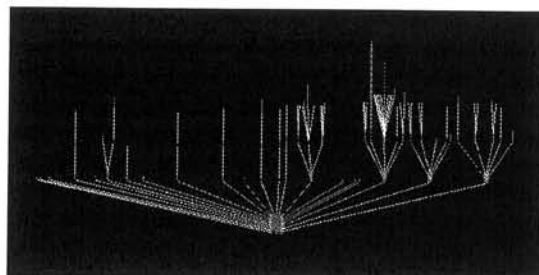


Figure 1a: A "bird's eye" view of portions of the library containing search hits

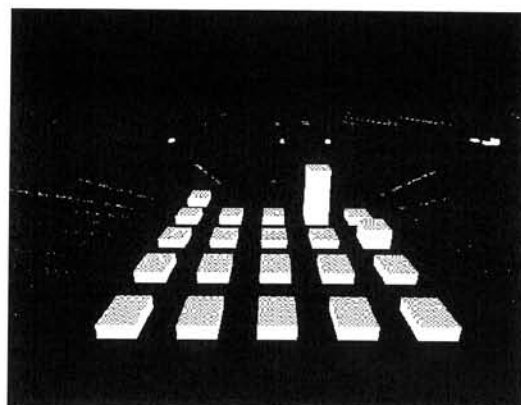


Figure 1b: 3D browsing view

The 'roadmap' of the relevant sections of the library is laid out as a tree, where the towns and roads along the branches indicate the classification hierarchy and the leaf towns contain the documents. For our test set, we used the Library of Congress classification scheme without the 'Cutter' extensions (the Cutter numbers run orthogonally to the hierarchical LoC system, and are mainly used to order documents within a given LoC classification). The root town of the search results, then, is connected to towns representing the highest level of the classification hierarchy (the 'A' to 'Z' call letters); these second level towns are connected to their appropriate sub-divisions (for example, 'A' has road a leading to 'AC'), the tertiary towns are connected to the appropriate number range subdivisions (for example, '1-315' and '316-800' of 'AZ'); and all documents of a numeric subdivision containing query hits are displayed in a leaf town of the tree. The depth of the displayed classification and size of the numeric ranges are collection-dependent, and will vary across portions of a collection. The main concern is to have the leaf towns of a size small enough to fit comfortably on a screen (say, having fewer than 50 buildings), and

large enough for browsing to be effective (say, having more than 5 buildings).

For non-leaf towns, there is a building corresponding to each 'road' connecting the town to the next lower level in the classification hierarchy. The height of a building represents the number of search 'hits' found at the lowest level of that portion of the hierarchy. Both building and road are labelled with the title of the LoC subheading that they represent [note: Figure 1b is too small to show the labels]. For leaf nodes, the 'buildings' represent individual documents (discussed further in Section 2.3).

Only those portions of the classification hierarchy containing matches to the query are displayed in full; the other portions of the library are collapsed to the highest level at which no query match occurs (for example, in Figure 1a the major subheadings 'E' to 'F' have been collapsed to a single node). We retain representations of the non-relevant portions of the library to keep the location of individual portions of the library as uniform as possible across queries, and to give as much context as we can as to what exists in the library.

2.2 Navigating and browsing

The user can fly freely over the information landscape created by the search, either following paths between 'towns' or zooming in directly on interesting portions of the countryside. For example, in Figure 2 the user has travelled to the town in the right background of Figure 1b. The tilt of the viewing angle and the viewer's distance from the ground can be adjusted.

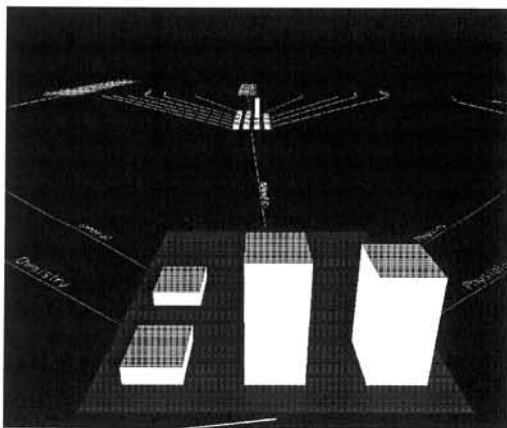


Figure 2: Zooming in on a portion of the library

This browsing mechanism has an advantage over conventional text displays of search hits in that it provides a visual sense of the groupings and subgroupings of search results. These groupings can be used to quickly winnow out portions of the retrieval set that are likely to contain 'false drops' (documents unrelated to the information need, whose retrieval is caused by lack of predetermined

term relationships or linguistic idiosyncrasies) (Shuman, 1992). For example, a search for 'SLR' might retrieve documents under the sub-headings 'Photography' (Single Lens Reflex cameras) and 'Computers' (Simple LR parsers). The user could quickly follow the classification hierarchy to the 'town(s)' of documents intended in the search, and ignore the 'town(s)' inadvertently retrieved by the second meaning of the query term.

2.3 Browsing a 'town' of documents

Each building in a leaf town of the query tree corresponds to a document in the collection (Figure 3), and is a *conceptual proxy* for that document (Rose 1993). Each building is labelled with the document title, and the building's appearance reflects further information about the document, where:

- building height represents document length
- the building's colour intensity corresponds to the document's age
- an icon on the roof gives an indication of the contents (eg, a scanned image of the book's cover)

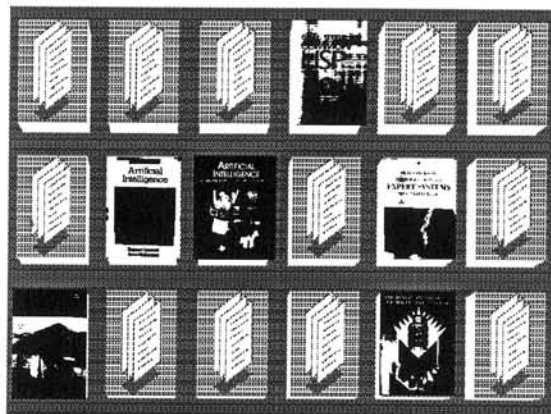


Figure 3: overhead view of document proxies

The buildings convey more information about a document, more quickly, than the text-only document descriptions in a convention retrieval system. While the old saying that "one cannot judge a book by its cover" contains an element of truth, in reality we quite often use the information gained from a quick glance at a book jacket to decide whether a book might suit our needs: for example, if I want a "scholarly" book, then the academic presses use quite different typesetting conventions from the popular publishers; if I'm looking for a detailed discussion of a broad topic, then a very thin book is less likely to be useful than a thick book; and if I'm working in a quickly changing field such as computing, then the older-looking books are likely to be obsolete. The process of navigating over a town is thus very similar to browsing a physical bookshelf, in that a number of different types of information about a document are apparent at a glance. The 'town' metaphor is perhaps superior, in that one generally

has to pull books out of the shelf to see more than their spines!

As noted in Section 2.1, a leaf town contains *all* documents bearing its classification code—including documents that do not contain the search terms, as well as the ‘hits’ that caused the town to be retrieved. Again, the intention is to facilitate browsing amongst documents falling under the same classification, as opposed to the more conventional displays that optimise the presentation of only those documents containing the search terms. Of course, the user will require a mechanism that will allow ‘hits’ to be quickly distinguished from the rest of the town. While this facility is not implemented in the current prototype, in the next the ‘hits’ will be marked as flashing or brightly lit buildings.

2.4 Selecting a document

What happens when the user selects a building/document as potentially relevant to the information need? Ideally, at that point the user would be presented with the full text of the document. At worst, an abstract, contents page, or other text sample should be available (as is the case in our prototype system). While the availability of full text would give the user the best possible opportunity to judge the document’s relevance (and would create a truly ‘virtual’ library), for performance and storage reasons full text is not practical for document collections of any reasonable size. However, an abstract or other sample of text is still useful when browsing, giving the user a flavour of the contents to aid in deciding the potential relevance of the document to the information need (Salton 1983).

III. Discussion

We have presented a novel interface design for browsing a collection of documents. Our system attempts to retain to the greatest extent possible the browsing facilities of a real, physical library—permitting recognition of books by their physical characteristics, and grouping the books by related classification. This interface enhances the physical library paradigm by supplying a visualisation of the classification hierarchy, and providing quick and convenient navigation capabilities. It gives all the advantages of a conventional online retrieval system in searching, but is better able to cope with poor search results. If the search returns too few items, a user can browse the ‘shelves’ near those responses. If it returns too many responses, the user is shown a structured collection—which will often immediately provide the basis for a quick refinement of the search. At all stages the user can see the documents they are interested in, in the context of the library as a whole.

The current prototype was implemented with the FSN visual file navigator, and is restricted to the display options of that system. As we further investigate the utility of this type of display, we wish to experiment with the physical layouts of the towns, and buildings within a town. For example: the hierarchical structure of the LoC classification system is displayed as a simple tree. This makes very poor use of screen (ground) area. We would like to investigate the trade-off between packing the viewing area and ease of comprehending the structure that is involved with different display styles. For example, we could display a hierarchy in a quadtree area-filling style, or we could base the display format on browsing a network of thesaurus terms (Pederson 1993), lattices of automatically generated document-term relations (Godin 1989), or a non-hierarchical *a priori* classification scheme such as Ranganathan faceted indexing (Lancaster 1972).

Similarly, the arrangement of buildings in towns could be modified to provide additional information about the “relatedness” of the documents. Rather than placing the buildings equidistant from each other (as in the current prototype), physical proximity could be used to represent intellectual proximity (by using statistical term co-occurrences to estimate the content similarity between documents).

Finally, in the prototype the interface is displayed on a conventional computer screen, and interaction takes place with a keyboard and mouse. We are particularly interested in investigating the potential benefits of using virtual reality technology—a stereoscopic viewer and data glove. It seems likely that eliminating the need to translate from a three-dimensional interface metaphor to a two-dimensional display would enhance the useability of the retrieval system. It would enhance the feeling of ‘context’ to have a wider field of view than is possible on a conventional screen, and to be able to ‘turn around’ to see back, up, or across the classification hierarchy.

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