Visualizing Metadata:

A Virtual Book Spine Viewer

Naomi Dushay

Cornell University, National Science Digital Library, 301 College Avenue, Ithaca, NY 14850, USA
naomi@cs.cornell.edu

Abstract. User interfaces for digital information discovery often require users to click around and read a lot of text in order to find the text they want to read – a process that is often frustrating and tedious. Because only a limited amount of text can be displayed on a computer screen, user interfaces rarely provide a non-linear, unstructured way to explore large information spaces or collections. We explore both information visualization concepts and traditional information organization concepts with an eye towards improving the user experience of computer mediated information discovery. We introduce the "virtual book spine" and our virtual book spine viewer, an application which allows users to visually explore large information spaces or collections while also allowing users to hone in on individual resources of interest.

1 Introduction

Information discovery has changed radically with the introduction of computerized library access catalogs, the World Wide Web and its search engines, and even online bookstores. Yet few instances of these technologies provide a user experience analogous to walking among well organized, well stocked bookshelves – something many people find useful as well as pleasurable. To put it another way, many of us have heard or voiced complaints about the paucity of "online browsing" -- but what does this really mean?

In traditional information spaces such as libraries, we can often move among the books and other resources. When we walk among organized, labeled bookshelves, we get a sense of the information space – we take in at a glance clues to the scope of the collection, the ages of resources, the frequency of their use, etc. We also enjoy unexpected discoveries: finding an interesting resource because library staff deliberately located it near similar resources or because it was miss-shelved or because we saw it on a bookshelf on the way to the water fountain.

When our experience of information discovery is mediated by a computer, we neither move ourselves nor the monitor, but what is displayed on the monitor changes. We have only the computer's monitor to view, and the keyboard and/or mouse to manipulate what is displayed there. Computer interfaces often reduce our ability to get a sense of the contents of a library: we often don't learn the scope of the library (its breadth, its quantity of materials/information), its density (how full the shelves are, how thorough the collection is for individual topics), the general audience of the materials (e.g., are the materials appropriate for middle school students or college professors, or …).

Some have used technology to replicate the appearance of physical libraries, presenting rooms of bookcases and shelves of book spines in virtual 3D environments [1] [2] [3]. This is a poor approach[1] as few book spines can be displayed legibly on a monitor screen. Instead, we will examine the role of book spines, call numbers, and other traditional organizational and information discovery concepts, and we'll explore how

[1] One possible merit of such an approach is in teaching traditional library concepts (such as organization by subject, call numbers, the circulation desk, the reference desk) to teenagers and younger children brought up on video games. Whether these traditional library concepts will remain useful or not is another question, beyond the scope of this paper.

computers and monitors can meet or exceed similar information discovery needs. Our hope is to tap the unique potentials of current technology to improve information discovery, to offer new services, and most important, to improve users' satisfaction. We need to capitalize on what computers do well, while bearing in mind the limitations of the computer. Our intent is to design GUIs to optimize utility and positive experience for the users.

2 A Brief, Recent History of Information Organization

If we want to provide a better sense of information spaces, it may be instructive to examine how libraries and bookstores are organized. Librarians have been pondering information organization for decades. Taylor puts it simply: "we organize because we need to retrieve" [4] . Svenonious states, "The essential and defining objective of a system for organizing information … is to bring essentially like information together and to differentiate what is not exactly alike" [5] .

We are so accustomed to the ways that libraries and bookstores organize information that we have the expectation that resources found close together will have some similarity. In both libraries and bookstores, materials are usually ordered by subject, with some exceptions for special formats or materials, such as maps, microfiche or rare materials. Moreover, we can usually determine some sort of subject context for a resource by where we find it – the location of the resource conveys information.

Organizational methodologies and technologies to support them evolved over many decades, if not centuries, to meet the retrieval needs of users of the materials, as well as the needs of those responsible for organizing, maintaining, and growing information spaces. This includes books, bookcases, bibliographic metadata and the technology to make them useful and scaleable such as card catalogs (a huge improvement over bound book catalogs), book spines and call numbers. We will now examine how libraries use classification systems and call numbers to group like things together according to their subject.

2.1 Call numbers and Co-location

In order to co-locate resources by subject, libraries use classification systems to assign "call numbers" which indicate a linear order for placement of individual resources on shelves. The two most popular classification systems for library materials in the United States are the Library of Congress Classification (LCC) and the Dewey Decimal Classification. In both cases, the classification scheme is a hierarchy of topics (i.e. broader topics can contain narrower topics), and sub-arrangements within each topic are possible (e.g. to group together different genres of material or to further organize by author). A particular resource's call number indicates an assigned classification topic -- it locates that particular resource within the topical hierarchy.

Because classification is used in libraries to assist in physical ordering of resources, in general only one classification number is assigned to each resource, based on what the cataloger determines is the primary topic of the book. While only the primary classification number is reflected in a resource's call number, additional subject headings from a classification scheme may be added to the bibliographic metadata to promote resource discovery based on other topics relevant to the resource. Call numbers need to be unique for circulation purposes, so there always must be some sub-arrangement and dating for editions and each copy of a resource must be distinguishable from all other copies of the same resource.

Bookshelves / book cases are a space efficient way to fit a linear ordering, such as one indicated by call numbers, in a more human suited space – a way to use more vertical space while preserving the linear ordering. There is an inherent tension between linear ordering and the non-linear space available. For example, there is some inequity in resource discoverability, as we are more apt to notice resources displayed in our comfortable field of vision: tall people may have difficulty reading book spines on low shelves, for example. In addition, there is tension between linear ordering and the hierarchical classifications.

Using call numbers, rather than words, to indicate classifications allows proximity to express similarity. That is, call numbers provide the linear shelving order, and resources having closely related primary topics have closely related call numbers. If the classifications were expressed in words, we would either need a special sorting order for thousands of classification "terms" or we would need to sort alphabetically, thereby losing co-location and its benefits. For example, "horse" and "pony" may be more closely related than "horse" and "hedgehog" but a consistent sorting order for thousands of such terms would be unwieldy to use, to say the least. In addition, terms can be ambiguous out of context: does "jaguar" refer to a cat or a car? The classification system disambiguates terms by placing them within its hierarchy, and there is no such ambiguity in the assigned classification numbers.

It should be noted that classification schemes define hierarchies that are NOT a strict tree structure: a classification topic often has "see also" and "see" references to guide users to related topics. These types of relationships between topics are not parent-child and therefore are not allowed in a strict tree.

3 Book Spines

We've just shown how a resource's location in a library conveys information about the resource's primary topic. Another way we get information about resources is from book spines, which often display some bibliographic metadata. In fact, there is a National Information Standards Organization (NISO) standard for "Printed Information on Spines." The abstract[2] claims, "this standard will help your users identify your product and use it!" by describing "what information to include and how to arrange it for maximum clarity" for "printed bindings, covers, containers …". Clearly there is a belief that certain bibliographic metadata aids user information discovery or organization. Note that book spines are multi-purposed: publishers may use them to visually "brand" their books, bookstores may use them to help sort books by topic, and then to order book placement on shelves by author, bookstore customers may use them to identify desired books, libraries might add call numbers, and library staff might use them for ordering while staff and patrons might use them for identification [6].

Just as a bibliographic metadata record displayed on a computer monitor is a surrogate for the resource, the book spine with its bibliographic metadata is also a surrogate for the resource. Obviously a book spine is closely related to the resource – you can't move a book without moving its spine. Nevertheless, the information on a spine is there to aid information organization and discovery without negatively impacting efficient book storage.

3.1 Virtual Book Spines – Can We Improve on Physical Reality[3]?

Rather than replicate the appearance of physical book spines, or even the specific information presented on them, we want to enable information discovery with a computer-mediated approach. We start by exploring new capabilities only available with non-physical, virtual book spines.

3.1.1 Virtual book spines can be in multiple locations simultaneously. In a virtual world, a resource can be "filed" in multiple places: it can have classification numbers (or disambiguated terms) assigned for all relevant topics. There is no longer a need to distinguish between the "primary" and "secondary" topics for a resource.

3.1.2 Virtual book spines can be organized for multiple characteristics simultaneously. For example, resources can be presented on a two-dimensional scatter plot, with the x-axis values corresponding to one characteristic (e.g. classification) and the y-axis displaying another characteristic (e.g. resource format). This allows resource proximity to be expressed for more than one characteristic: two objects near each other in our two-dimensional scatter plot would have similar classifications AND similar formats. The location of the resource in the plot conveys two

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[2] http://www.niso.org/standards/standard_detail.cfm?std_id=526
[3] With a nod to Ben Shneiderman [7]

characteristics, even when there are no other resources in close proximity, from the plotted x and y values. It is possible to use location to convey three characteristics instead of two using a three-dimensional rendering.

3.1.3 Virtual book spines can be re-organized instantly at the behest of any user. Reordering data presentation can be is as easy as a mouse click or two. It is easy to provide a way for users to change the sorting order of a characteristic (e.g. from ascending to descending), or the characteristics assigned to the axes in a scatter plot display. Moreover, users can tailor the presented organization to suit their individual needs without interfering with others' needs – even library staff would be able to create views tailored for their purposes without adversely affecting library patron views.

3.1.4 Virtual book spines can be visually richer than physical book spines. Many of today's students have never lived in a world without computers. Graphical metaphors are familiar to them, and keyboards, mice and other input devices pose no confusion.

- *Graphics:* Rao [7] suggests we put graphics ahead of text. The most popular personal computer operating systems and programs use a variety of graphical icons in order to fit more information onto the display, and to put more utility at the user's fingertips. This is true even in word processing programs designed to manipulate text. Hawkins [8] claims the "human eye interprets visual data much faster and more effectively than text", so resource discovery and/or user satisfaction might be well served if virtual book spines can utilize graphics effectively.

- *Basic visual characteristics:* Color and size are easily perceived by most users [8], and might be mapped to metadata characteristics to compactly but clearly convey information. In addition, shape, texture, rotation and other visual characteristics might also be used to convey information. Information visualization tools, such as Spotfire DecisionSite[4] and Inxight's Star Tree,[5] are generally designed to allow color, size and other characteristics to convey information.

- *Multiple styles:* While it's true that physical book spines are inconsistent in the information they provide, the inconsistencies are generally due to customs at different publishers rather than choices made by the libraries or bookstores to serve end-users. Even when libraries re-bind books for preservation or other reasons, the appearance of the resulting new book spine may provide different information than the previous, again generally without end-users in mind. Virtual book spines, however, might have deliberately distinct groups of characteristics indicated by their appearance. For example, a music collection might want to indicate title, composer and performer for classical recordings, title and performing group for popular music recordings, title and composer for printed music, while a math collection in the same library system might want to display author, title and subject information for all of its holdings. So the virtual book spines for different groups of resources within a single large collection might deliberately present different information to the user.

3.1.5 Text can always be oriented correctly: For most languages, printed text reads horizontally, but books are usually stored vertically. This means book spine text is often encountered sideways or text must be short enough to fit within the width of the spine. Virtual book spines could be designed with the text orientation in mind: virtual book spines with Japanese text could have a vertical orientation, while book spines with English text could have a horizontal orientation.

3.1.6 The size of a virtual book spine is arbitrary*:* unlike physical book spines, virtual book spines are not constrained by the size of the resources themselves. So displaying 12,000 book spines on a single monitor is possible by making our virtual book spines tiny – each spine's location in a

[4] http://www.spotfire.com/products/decision.asp
[5] http://www.inxight.com/products/oem/star_tree/

scatter plot would still convey information, and color may be distinguishable with only a few pixels. Conversely, if we only have one or two virtual book spines to display, we could display a great deal of legible textual information with each spine. A virtual book spine might even appear larger than a corresponding physical book spine, depending on the monitor size, font size, etc.

3.1.7 **Context sensitive appearance**. The appearance of virtual book spines could appear different in different contexts. The context differences might pertain to the density of resources in a GUI (see 3.1.6 above) or to individual user needs or preferences, or to the path of access (e.g., a virtual book spine seen from nsdl.org might look different than the same virtual book spine seen from mathworld.org.), among other things.

Before we can create useful virtual book spines, we need to understand the context of the information space, the "grain" or inherent structure of the information [7], and as much as we can about the intended users and the goals and requirements for our user interface.

4 Our Context: the National Science Digital Library

The National Science Digital Library (NSDL) is a wide-ranging program of the National Science Foundation (NSF) to build library collections and services for all aspects of science education [9]. The NSDL has a very broad intended target audience, from "K to gray:" students, instructors, the public at all levels, librarians, NSDL federated partners, community interest groups, etc., and is intended to have very large quantities of users and resources. In order to integrate the individual NSDL projects and other relevant information into a coherent, large-scale digital library, the NSDL Core Integration team has created a robust, centralized Metadata Repository (MR). The MR contains bibliographic metadata pertaining to resources in the fields of science, technology, engineering and mathematics, from NSDL participating partners as well as from non-participating open-access web resources. Note that the MR does not store copies of the resources themselves – it stores only the *metadata* for those resources.

The MR uses a two-tier model comprised of "*collections*" and their "*items*." A single item may be large or small, may itself contain parts or smaller units, and can range from simple web sites to image files to datasets to large and sophisticated digital libraries. A collection is defined as an aggregation of (NSDL) items, although collection records may describe collections of digital resources for which there is no available item metadata. Associating every individual item with a collection, though fairly primitive as an organizing principle, allows for some simple assertions of resource quality based on the reputation and practices of the entity responsible for the collection.

Collections in the NSDL may have a small icon brand image unique to their collection. These brand images may be displayed to users along with collection or item metadata. For example, brand images are displayed in NSDL search results (see Figure 1).

Aside from differences in item granularity and quantity, the quality of resource metadata in the MR varies greatly. As described in earlier papers [10] [11], the NSDL architecture is based on the recognition that, with a library of this complexity, it is impossible to impose detailed requirements for metadata standards that every collection must follow. Instead, the NSDL must accommodate a wide spectrum of metadata quality, anticipating a wide variety of errors or inconsistencies [12].

4.1 NSDL User Interfaces

NSDL end-users are not expected to interact directly with the MR; instead, user interfaces access services such as the NSDL search service, which processes the MR contents. Due to its very broad intended audience, the NSDL has always intended that there would be multiple UIs; different UIs may be targeted for different groups of users, or for different user tasks.

In the context of libraries, two of the most commonly mentioned user tasks are "search" and "browse" -- but it's too limiting to use only two terms to describe information discovery and retrieval activities. Our ideal is to support many user tasks and user groups; at the present time the main public entrance to the NSDL[6] has three user interfaces which are fundamentally about presenting NSDL MR contents, or information about MR contents, to users. We will briefly describe each of these interfaces, and then go on to discuss our prototype virtual book spine viewer. Note that one goal these NSDL user interfaces have in common is to convey the sense of a single library with many collections across many subjects.

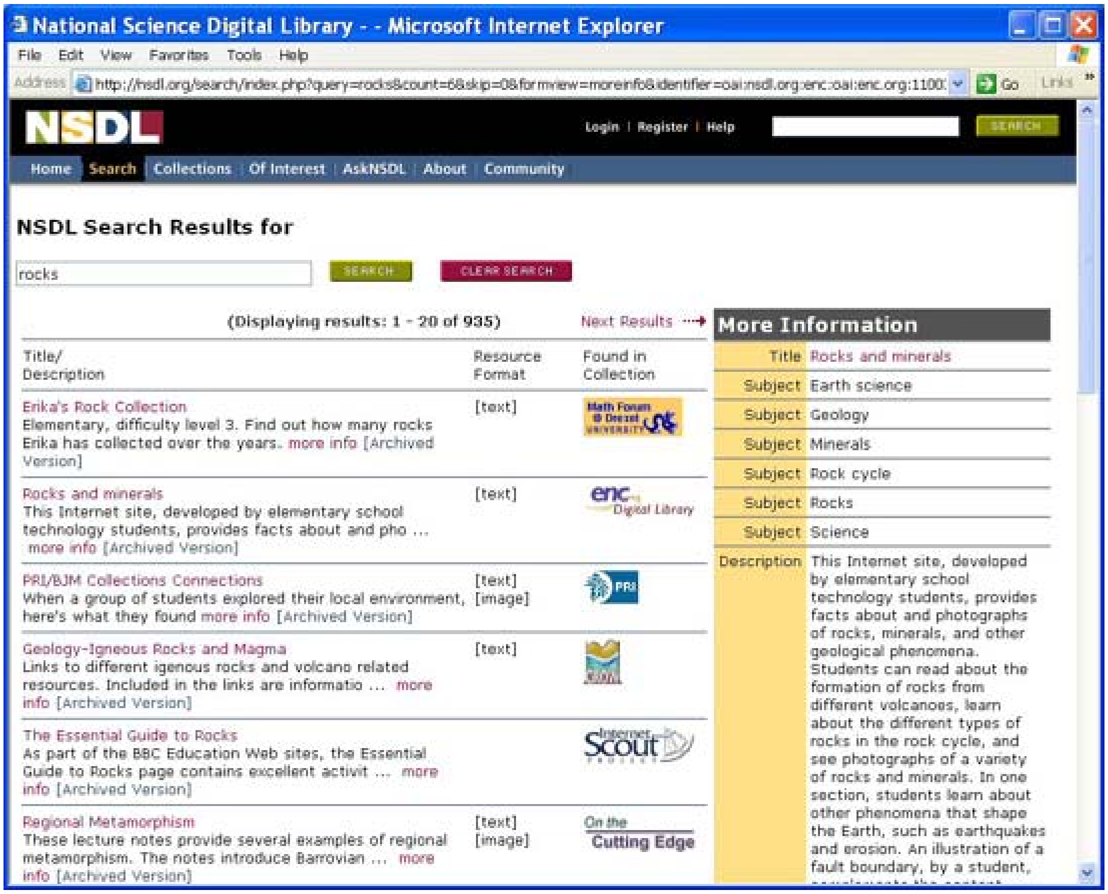

Fig. 1. NSDL Search Results with "More Information" panel visible

Figure 2 shows the NSDL Search request form. We'd like to emphasize a few aspects of the search UI. Users can filter their searches in two ways: by resource format and/or by record type (collection or item). Search requests are sent to the NSDL search service, which returns information about resources deemed appropriate for the query. As we saw in Figure 1, search results display resource title, brief description, the format of the resource, and a brand image indicating the collection providing the resource's metadata to the NSDL. Clicking on the more info link in a search result displays the metadata record in the MR corresponding to the search result, while clicking on the title in the search result will connect the user directly with the resource in a new window.

The NSDL offers nothing labeled as a "browse" UI, but it does provide two ways to explore collections in the NSDL. The alphabetical list of collections[7] (not shown here) displays descriptive text and information about the scope of each collection in the MR, while the "NSDL At a Glance"[8] (Figure 3) is an interactive visual view of the MR collections organized into a tree by subject, implemented using Inxight's Star Tree.

[6] http://nsdl.org
[7] http://crs.nsdl.org/collection/
[8] http://nsdl.org/collections/ataglance/browseBySubject.html

Notice that the brand images and the collection titles are chosen for display. The collection description is available as a tool tip, appearing when the mouse hovers over a collection node in the tree; double clicking on a collection node will connect the user directly with the collection's URL in a new window.

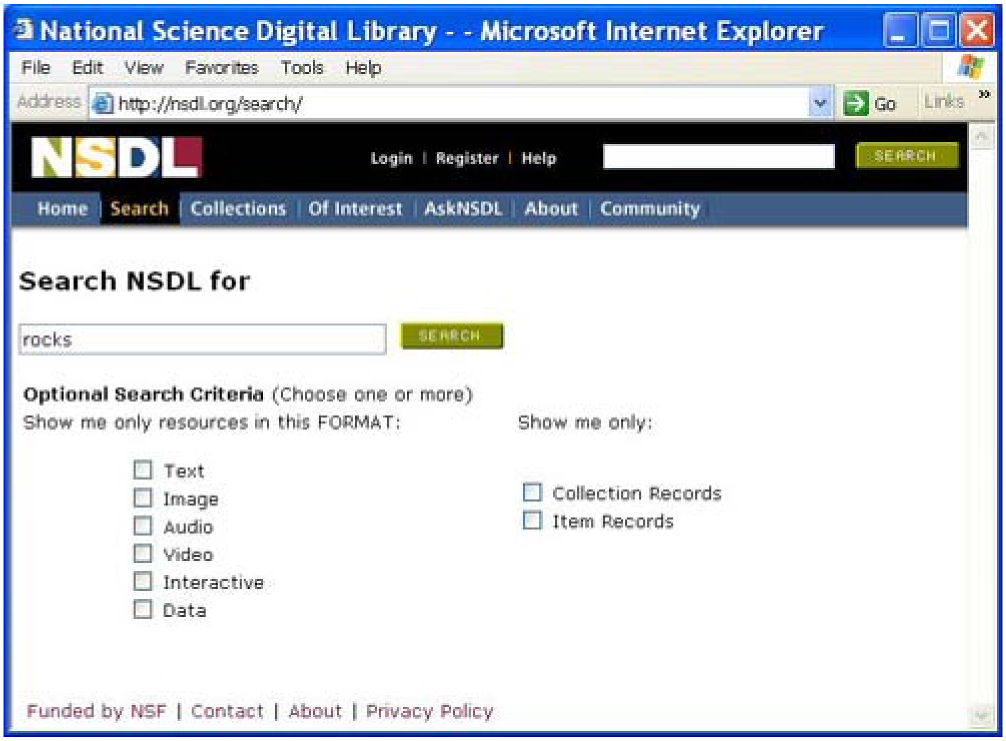

Fig. 2. NSDL Search Request form

The "At a Glance" hyperbolic tree is a way to present the NSDL information space graphically, relying on arrangement of information and how it moves together to convey meaning to the user, in addition to providing text. Users can interact with the Star Tree, changing which part of the tree is displayed in detail and performing searches, but they can't change the information in the tree or its structure. We propose another user interface, which allows users to hone in on resources of interest to them and presents information akin to that seen on book spines. Our interface might be used to get a sense of the information space, of parts of it, to get an overview of a large number of resources at once, or even to get detailed information on a few resources of interest.

5 Virtual Book Spine Viewer – Our Alpha Prototype

One of the goals of our virtual book spine viewer is to present information corresponding to shelves of book spines with a computer monitor, capitalizing on the advantages of the computer interface and staying aware of its limitations. We hope to create a user interface that meets some under-served information discovery needs.

5.1 General Notions Informing Our UI Design

Many computer interfaces for information discovery require users to scroll through long lists, to click around and to read a lot of text to find the text they want to read. Text features of resources are almost always presented alphabetically, and the number of items in the lists can be very long. Alphabetical ordering is certainly an improvement over no ordering, but it generally has no bearing on features with an inherent non-alphabetical ordering (e.g. dates of historical events, or ages of intended audience members), nor does it necessarily group similar items together. It's analogous to one of the most familiar complaints about dictionaries: needing to know how to spell a word in order to look up how to spell it in the dictionary. Rao urges a graphical or iconic approach [7], which allows users to see patterns, to get a sense of the information space with a small amount of reading, and may also make better use of monitor real estate. "The human mind can usually make some initial judgments with visual paradigms that allow analysis of the entire information space" [13].

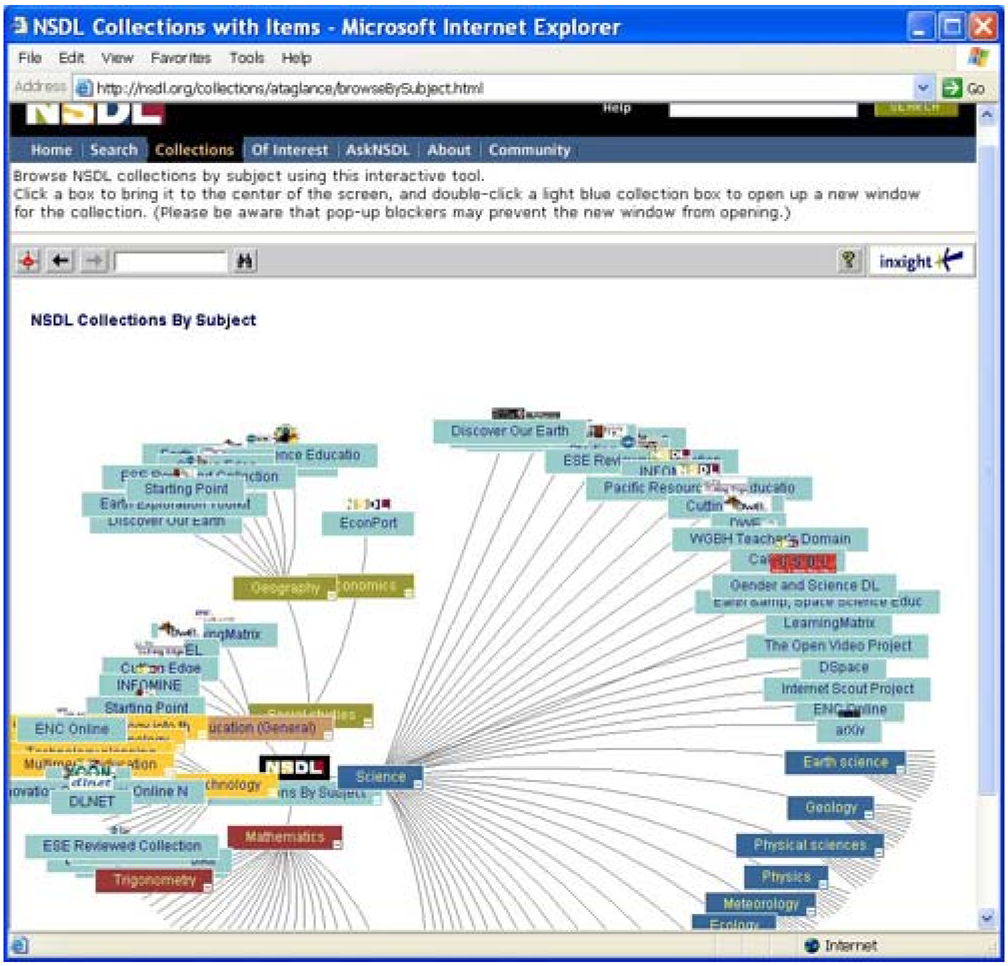

Fig. 3. "NSDL At a Glance" with Inxight's Star Tree

We agree with Raskin's notion that there is no such thing as an "intuitive" interface; rather interfaces can be "very easily learned" perhaps due to familiar metaphors, or simple interaction needs, or good UI design [14]. This presents a tension between providing a UI with new capabilities and sticking with the familiar.

Allowing users to interact directly with the information resources, rather than with the computer, is another highly desirable feature [7][13]. However, as we suggested in earlier sections of this paper, our interface will be presenting virtual book spines, which are a surrogate for the information resource. We intend to provide a semantic zoom, or "progressive disclosure" [13] on the surrogates in order to provide users with appropriate information in appropriate quantities whenever possible. At the same time, we want to provide stable and consistent visual areas to help the users navigate easily and remain oriented.

5.2 Design Issues Specific to the NSDL Context

We have already mentioned a number of salient characteristics of the information stored in the NSDL MR. In many cases, the inherent structure of the information we'd like to display suggests a particular approach for our virtual book spines and/or the viewer.

5.2.1 **Subject hierarchy → folder metaphor**. We've already presented a strong case for presenting our resources organized by subject, and we know subject classification schemes are hierarchical. However, subject classifications do not define a strict hierarchy: some topics would like to have multiple parents, some topics are closely related to topics in another part of the tree while "see also" and "see" topics are direct references to other places in the tree. While strict hierarchies are elegantly expressed as tree graphs such as Inxight's Star Tree, the folder metaphor with "short cut" link objects is a familiar way to present less strict hierarchies.

5.2.2 **NSDL collections and items→ NSDL collection brand images**. As with NSDL search results, we want the virtual book spines to graphically indicate the provider of each metadata record. A collection's brand image can be associated with each NSDL resource, expressing the provider of the individual metadata record and collectively connoting the organization of NSDL resources into collections.

5.2.3 **Brand images→ zooming user interface**. Images tend to work well in zooming user interfaces (ZUIs) [15] [16] [17] -- generally easy-to-learn interfaces with a familiar metaphor providing focus plus context. When a user wants more detail, s/he can zoom in; when s/he wants less detail, s/he can zoom out.

5.2.4 **Inconsistent, multi-faceted metadata→ scatter plot with user manipulable axes**. Scatter plots are an excellent way to organize information by two characteristics simultaneously. We also know that the metadata in the MR is of inconsistent quality, often missing information or having inconsistently applied controlled vocabularies. By allowing the user to manipulate the scatter plot axes assignments, the virtual book spines displayed can be sorted by the two characteristics most meaningful to the user for the specific set of metadata displayed.

5.2.5 **Categorical resource format information→ format represented by color**. As is clear from the NSDL search query page (referral to figure), resource format is important to NSDL users. Because the preferred DCMI Type controlled vocabulary[9] for resource format has a small number of possible values, and because the controlled vocabulary is often supplied or can be provided, resource format is an excellent candidate to be mapped to the color of virtual book spines.

5.3 Our Alpha Prototype Viewer: A Scatter Plot ZUI

Figure 4 shows our alpha prototype virtual book spine viewer implemented as a java application. We borrowed from GRIDL[10] [18] for the overall layout of and structure of our application, used Piccolo[11] [15] for the ZUI code, and used the Infovis Toolkit[12] [19] to implement the scatter plot.

On the left, a two-tiered subject hierarchy[13] is presented with the folder metaphor. The middle shows a scatter plot of virtual book spines for NSDL resources that match the selected subject folder. The scatter plot has user manipulable axes, and is a zooming user interface. The virtual book spines have the brand images for the collection providing the metadata to the NSDL MR, and are color coded by resource format

[9] http://dublincore.org/documents/dcmi-type-vocabulary/
[10] http://www.cs.umd.edu/hcil/west-legal/gridl/
[11] http://www.cs.umd.edu/hcil/jazz/
[12] http://www.lri.fr/~fekete/InfovisToolkit/
[13] Currently, the NSDL uses a subset of the Gateway to Educational Materials (GEM) subjects (http://search.thegateway.org/)

– two characteristics emphasized in the NSDL search form and the search results page. The virtual book spines also display the title of the NSDL resource. Our implementation of the alpha prototype allows for easy creation of different virtual book spine representations by the application developer.

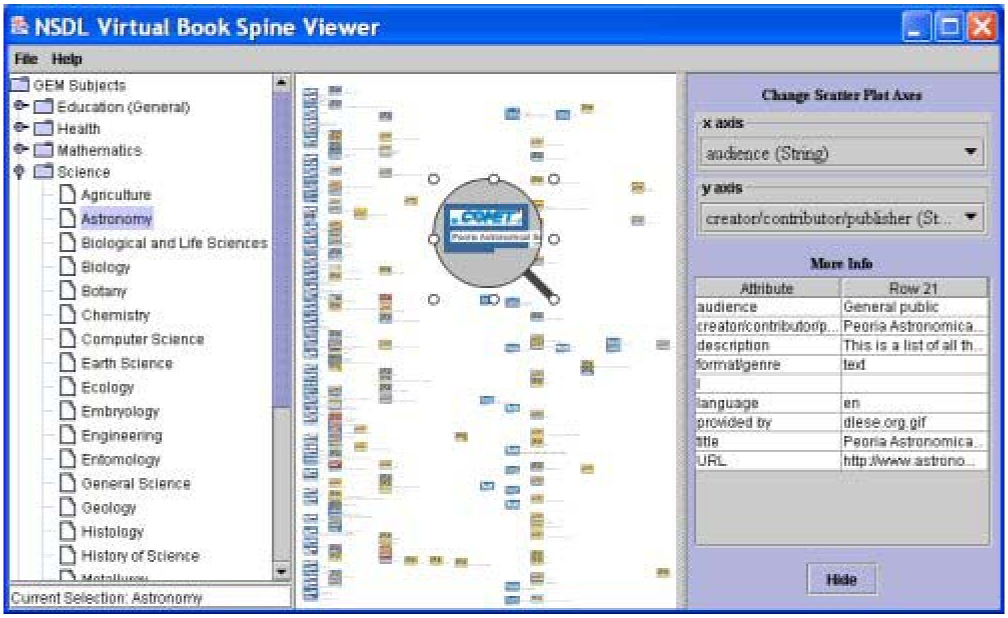

Fig. 4. Virtual Book Spine Viewer

The viewer allows a number of ways for users to interact meaningfully with the virtual book spines and how they are displayed. A user can choose any subject folder in the left panel to get metadata for resources corresponding to the selected subject. The consistent left panel display of the selected subject folder and its place in the subject hierarchy helps avoid user disorientation or loss of context. The user can assign any from a number of resource characteristics for the x or y axis, including audience, additional subjects, creator/contributor/publisher, format, language, metadata provider and title. This allows exploration of the distribution of resources across the information space according to user-selected characteristics. The user can use the provided magnifying glass to look more closely at an area of the scatter plot, and the user can also zoom in or zoom out in the scatter plot (see Figure 5). Clicking on a virtual book spine in the scatter plot displays the resource metadata in the right side detail panel, analogous to the "More Information" panel in NSDL search results; double clicking on a virtual book spine opens a web connection to the resource's URL, if there is one – users can smoothly travel from the resource surrogate to the resource itself.

With the viewer's scatter plot, users can identify the collections and formats of many resources at a glance, can get a sense of the density of the information space (is it a densely or sparsely populated category in the NSDL?), and they may also arrange the virtual book spines to highlight many other characteristics of interest.

With the zooming interface, users can choose information that suits their immediate needs. When the individual virtual book spines are tiny, they may appear as little more than specs. However, the location of each spec-sized virtual book spine in the scatter plot conveys information about the two characteristics chosen for the axes. When the virtual book spines are a little larger, color (which indicates resource format) can be discerned, in addition to location. Once we have zoomed close enough for color to be discernable, we may be able to get a sense of the distribution of the formats of the resources represented by the virtual book spines. Zoom in a little closer, and though we may not be able to see all the details of a brand image, we can still discern its basic color(s) and pattern which distinguish it from other brands. As we zoom yet more, we can make out details in the brand images, which sometimes have text in them. Similarly, while zooming in, a virtual book spine's title may first appear as a pattern of lines and spaces, but eventually the text becomes legible.

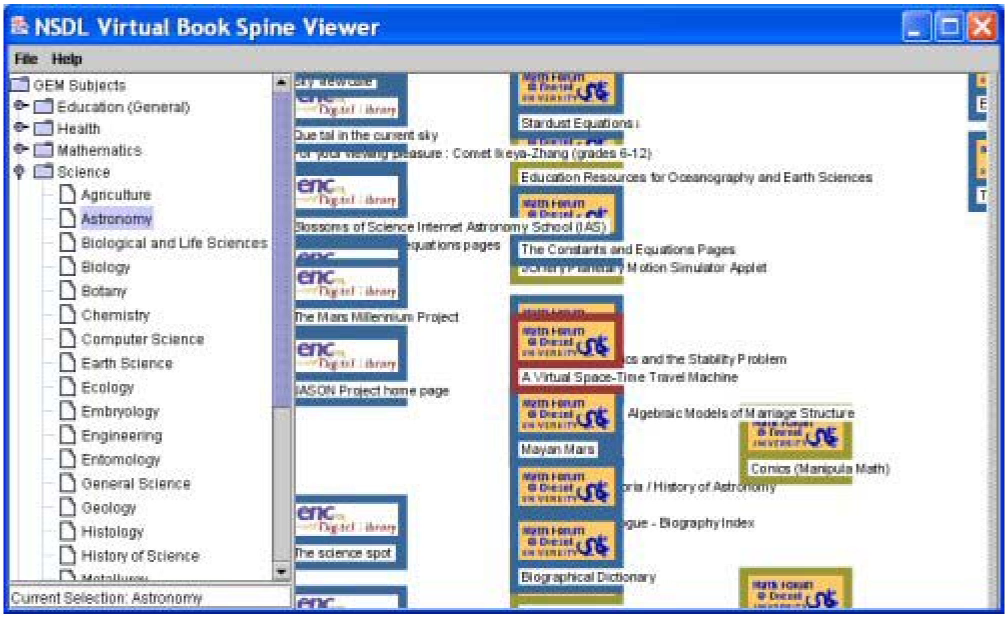

Fig. 5. Zooming in on some Virtual Book Spines

5.4 A New Presentation of Search Results

We can also use the virtual book spine viewer to graphically, interactively present search results (see Figure 6). We simply remove the folder hierarchy on the left side of the viewer prototype, and display virtual book spines corresponding to the search results. The zooming scatter plot has all the same advantages as outlined above: users can organizing the presentation of results by selecting characteristics for the axes, they can zoom within the scatter plot to get the level of information that interests them, from an overview of their search results to getting details on particular clusters of virtual book spines. Users can single click on a virtual book spine to see the full metadata, and double click to go to the resource itself.

6 Conclusions and Future Work

We believe the virtual book spine viewer and the virtual book spine approach have great potential in an increasingly digitized, computer mediated world of information discovery. At the same time, we are well aware of the urgent need for a user centered design process for the viewer application. The design of the virtual book spines and of the viewer will benefit greatly from many iterations of user feedback and newly designed prototypes. Among other concerns, we are particularly interested in user feedback on what virtual book spines should look like, how many virtual book spines can usefully be displayed in the viewer, how virtual book spines should appear when zooming to different levels of detail, and if there is an optimal density of virtual book spines [17]. It may also be useful to provide alternate visualizations or views of the virtual book spine data. One possibility is a table view, allowing users to sort by any combination of columns to organize the data, and perhaps using Fisheye Menus[14] for scrolling.

[14] http://www.cs.umd.edu/hcil/fisheyemenu/

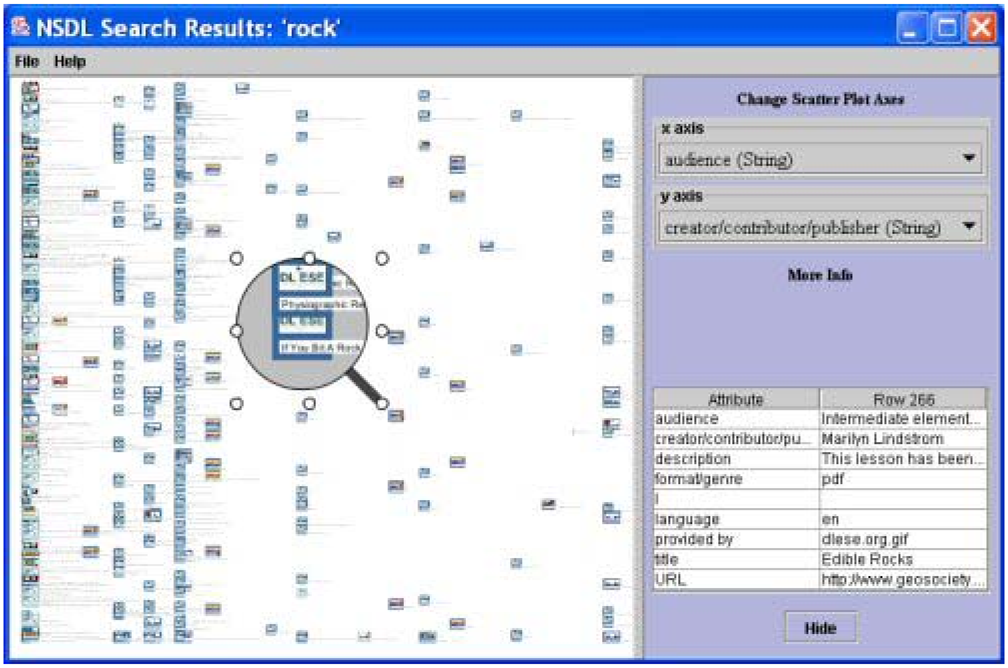

Fig. 6. Virtual Book Spine Viewer showing all 935 NSDL Search results for 'rock'

User feedback is vital, but even without it we have a long list of ideas and improvements to implement, such as a) displaying axes values, b) allowing searches on the text associated with displayed virtual book spines, c) better indicating when multiple virtual book spines map to the same spot in the scatter plot by using slight displacement, often referred to as jitter, and d) allowing users to select more mappings for display characteristics, such as virtual book spine color or shape in addition to the axes.

Some interest has already been expressed for customizable versions of the prototype, and we fully intend to create a free, open version of the source code that is more configurable. Three improvements along these lines will be 1) loading the left panel hierarchy in the viewer from a schema-validating XML file, 2) loading data for the scatter plot display from any comma or tab separated (.csv) text file and 3) allowing an easy way for installation specific virtual book spine mappings and appearance.

Our explorations with the virtual book spine viewer prototype have highlighted the benefits of consistent metadata using controlled vocabularies. To this end, the NSDL is working with partners to provide missing metadata for NSDL resources. INFOMINE[15] is to provide LCC subject metadata generated automatically from a resource's metadata and its full text, if available for crawling. The Eisenhower National Clearinghouse (ENC)[16] will also be enhancing NSDL metadata to support the filtering of NSDL resources by grade level or content pertaining to educational standards.

We also aspire to subject classification visualizations that are useful both to end-users and to collection organizers. We'd like richer subject classification schemes to be more accessible, for example using a subset of LCC rather than the limited subset of GEM subjects the NSDL currently uses in some contexts.

In short, we believe the pairing of information visualization techniques with bibliographic metadata will yield great benefits for information discovery.

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[15] http://infomine.ucr.edu/

[16] http://www.enc.org/

7 Acknowledgements and Disclaimers

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