Direct Multidisplay with MultiBrowser

ABSTRACT

We present (1) a framework, (2) a formalization, and (3) an implemented system, all addressing the "direct multidisplay" concept. A user study favorably compares a novel system component, color bars, with text-based search engine return lists for document similarity judgements. The system, MultiBrowser, is intended for an information foraging style of hypermedia browsing.

We classify the display technique of MultiBrowser as direct multidisplay, contrasting it with indirect multidisplay, direct monodisplay, and indirect monodisplay, and formally explore its potential.

MultiBrowser incorporates the following characteristics to support creation of, and foraging within, hypermedia repositories: colored bars that provide visual document summaries, links among similar paragraphs without regard to document boundaries, automatic repository creation from Web search engine queries, automatic hyperlink and anchor insertion, and multiple simultaneously displayed windows onto the repository.

Keywords

Browsing, foraging, formalization, multidisplay, repositories, visualization.

INTRODUCTION

Hypertext-related activities like Web browsing offer unparalleled convenience for browsing compared to traditional activities like going to the library. Yet browsing currently still does not completely satisfy the goal of frustration-free access to the right information at any time. Because interaction efficiency between human readers and documents continues to be an important problem, research in information retrieval continues to address technologies for finding texts via various text processing strategies. User interface techniques from sophisticated visualizations to simple bolding of query term occurrences form a complementary research area that helps address the same goal. Interaction with documents to enable efficient location and absorption of relevant information has traditionally been supported by tables of contents, indexes, suitable writing style and good document organization. More recent forms of support are enabled by digital document storage, and include full text search, hypertext and hypermedia, and user interfaces. Helping users locate passages is increasingly important because readers of on-line text tend to scan and pick out passages rather than reading in a traditional sense (Nielsen 1999 [18]).

One goal of MultiBrowser is to provide users with support for interacting with a repository compiled from documents, such as those retrieved by a search engine query, or those specified in a predefined document list. A second goal of MultiBrowser is to provide a modern demonstration of the feasibility of the *direct multidisplay* concept as a system design strategy which we can modify as needed. A third goal is to explore a supporting visualization strategy for efficient document similarity judgements. The goals of the current report are similar. One is to describe and analyze the direct multidisplay concept, the second is to describe its instantiation in MultiBrowser, and the third is to report on the just-mentioned visualization technique.

BACKGROUND: COLLAGE DISPLAYS

In MultiBrowser, clicking on a link typically brings up a collage of several non-overlapping hypermedia-containing subwindows, so links are conceptually one-to-many. Each collage provides a view of a repository (Figure 1).

Collage-based displays have been a key aspect of a number of previous reports. The NoteCards system (Halasz 1988 [6]) and the Sun version of Hyperties (Shneiderman 1987 [21]) could display several information items on the screen at once. The term "collage" for such a display seems to have originated later with Kaltenbach and Frasson (1989 [9]), who describe a system for presenting mathematical proofs which was later extended to presenting hypertext (Kaltenbach et al. 1991 [10]).

The present work focuses on collages that are space filling and without overlaps. Notable recent works in this area are the Krakatoa Chronicle online newspaper (Kamba 1995 [11]), the VOIR interface which is also based on the newspaper metaphor (Golovchinsky and Chignell 1997 [5]), and Elastic Windows (Kandogan and Shneiderman 1997 [13]). Notable early works include the Hyperties (earlier TIES) on-line encyclopedia (Lifshitz and Shneiderman 1987 [15]).

At least two studies suggest that non-overlapping, space-filling windows are better than overlapping windows for displaying text. In one, Bly and Rosenberg (1986 [2]) showed that such a windowing strategy supports faster identification of task-relevant paragraphs than an overlapping window strategy when it is possible to present the bulk of the source material without overlapping. In the other, Kandogan and Shneiderman (1997 [12]) investigated

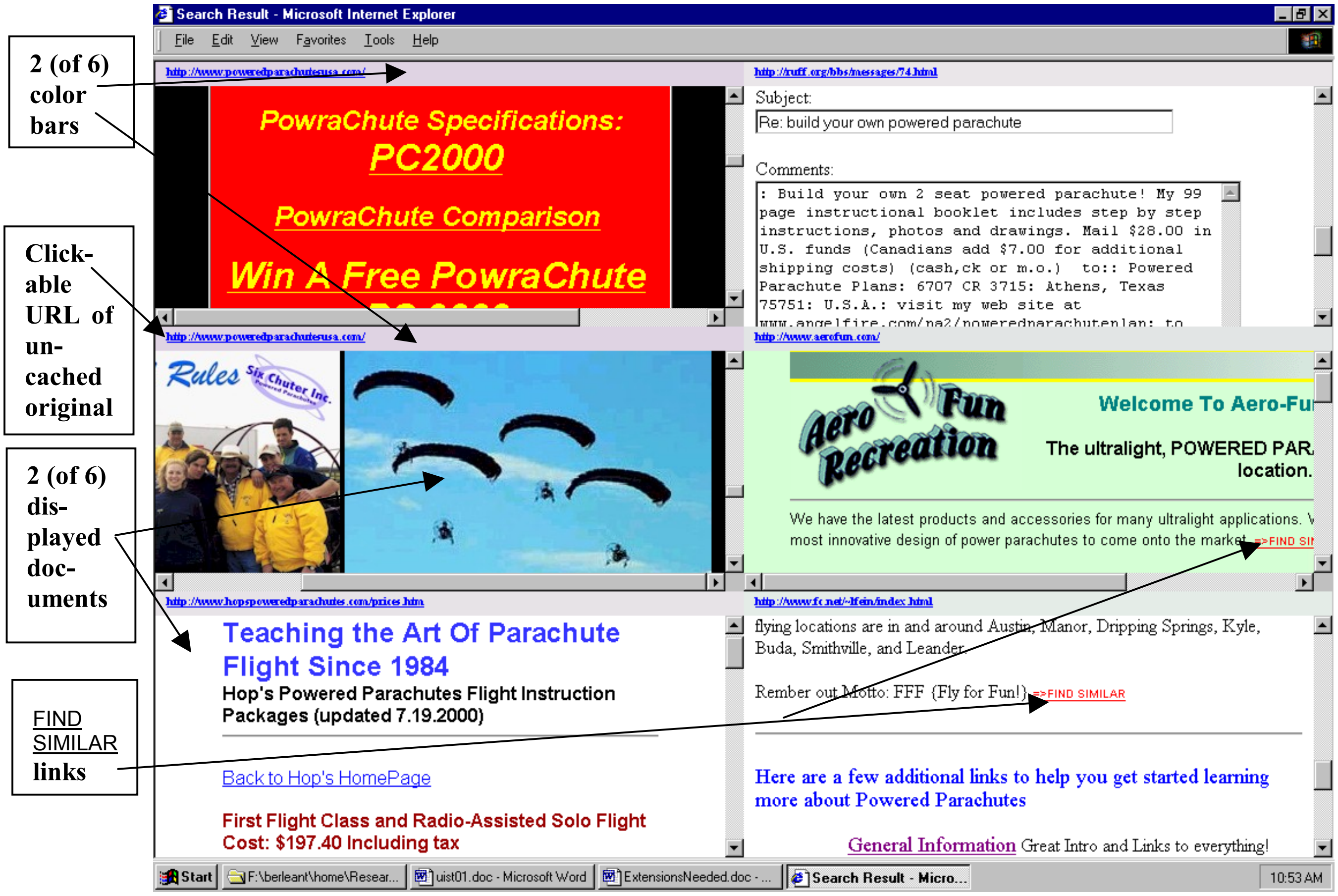

Figure 1: **Sample MultiBrowser screen from a repository processed from documents obtained by the Web search engine query "powered parachuting" (we do not endorse any company mentioned therein). Six subwindows each display a passage in a document of the repository. Each subwindow is scrollable to other parts of the document in that subwindow, and clicking its URL at the top of the subwindow loads it into the entire browser window. Each URL is within a colored horizontal bar (poorly rendered in print as gray) whose components of red, green, and blue encode the nearness of the document in the subwindow to the centroids of the 3 document clusters in the set of documents. The color bars supplement the displayed passages with gestalt information about their containing documents.**

completion times for 21 task conditions, finding that their "Elastic Windows" windowing method enabled faster task completion than overlapping windows.

FROM MULTIDISPLAY TO DIRECT MULTIDISPLAY

The MultiBrowser interface is a multidisplay, by which we mean each subwindow shows information separately (Figure 1). Collectively the subwindows provide a view of the repository. The goal is to provide a custom view that meets the needs of a particular user at a particular moment [1]. Interactive navigation through the space of these views constitutes browsing. Navigation is by scrolling within a subwindow and by clicking, usually on a hyperlink compiled into the repository and pointing to a new view of the repository consisting of a different set of subwindows.

The MultiBrowser interface exhibits both what we will call *direct* display (presentation of actual information, rather than phrases or icons representing actual information), and *multidisplay* (display of more than one thing at once). Multidisplay and direct display, used together, constitute *direct multidisplay*. The next section discusses these in more detail.

DIRECT DISPLAY AND INDIRECT DISPLAY

Definition: *direct display is the presentation of actual content.*

An example of direct display is presentation of text from a document. In contrast, an example of indirect display would be display of a descriptive textual or iconic hyperlink.

Definition: *indirect display is the presentation of meta-content.*

By meta-content we mean information about content rather than content itself. An example is a list of references returned by a bibliographic search system. Such systems provide such meta-content as titles, authors, and brief extracts whose main purpose is to help the reader decide whether to access the full document itself. Such meta-content has also been called document surrogate material (Hearst 1999 [7]).

The distinction between direct and indirect display is blurred by the possibility that direct display may not be able to display the entire item, since an item could be sizeable, as in the case of many documents. Then the part that is displayed constitutes both a direct display of part of the document, and an indirect display describing likely content of other parts. Blurring may also be a design objective, as in Zellweger et al.'s (1998 [26]) fluid links. Finally, blurring can occur when the needs of the user can determine whether displayed information is direct or indirect − a bibliographic reference is indirect information to someone who needs the paper itself, but direct information to someone who merely needs to know when it was published.

Advantages of Direct and Indirect Display

When actual content is needed, direct display is better, while in cases where the resource-saving or abstraction capabilities of indirect display are more important, indirect display is better (Table 1).

	Direct display	Indirect Display
Ease of access to content	Higher	Lower
Summarization	No	Possible
Display "footprint" per item	Higher	Lower

Table 1. Some +'s and −'s of direct and indirect display.

The current widespread reliance on indirect display should trend downward as network bandwidths and display device capabilities increase (see item 2 on next page) because the space-saving and network bandwidth advantages of indirect display will consequently tend to become less important.

From a cognitive standpoint, the abstraction and summarizing capabilities of indirect display can be important. However if space exists to display the actual item, then also displaying a summarizing indirect display of it would entail only a modest additional space overhead.

MULTIDISPLAY AND MONODISPLAY

Definition*: a multidisplay is a non-overlapping, space-filling collage of two or more presented information items.*

Multidisplays are a type of collage-based computer displays. An alternative to multidisplay is monodisplay.

Definition: *a monodisplay is the presentation of one item.*

Information retrieval systems usually use monodisplay to display content from a document. For example, typical Web search engines respond to a query with a list of URLs, from which the user chooses one item to view at a time. When the user needs to see only one item, and the item is large enough, and there is no particular advantage in seeing more than one item, monodisplay allows the entire display area to be devoted to showing the item. On the other hand, when it is useful to see more than one item simultaneously, and the items are small enough that more than one will fit completely within the display, multidisplay seems preferable. An example is if there is a need to make a choice among items.

Formalization of multidisplay. Let P_1 be the probability that the item most likely to be of interest of all the displayed items is, in fact, of interest. For example, if the items are displayed because they match a query, this would be the item that matches best. Then the probability that this most likely item is NOT of interest is $1-P_1$. Similarly, if P_n is the probability that the nth most likely item to be of interest is in fact of interest, then the probability that it is not is $1-P_n$. Then

p(*none of the displayed items is of interest*)

$= (1-P_1)\,(1-P_2)\ldots(1-P_n)$.

Therefore, define P as

P=p(*at least one displayed item is of interest*)

$$=1 - (1-P_1)(1-P_2)\ldots(1-P_n) \qquad (1)$$

If all of the candidate items have a reasonable probability of being of interest, then P rapidly approaches 1 as n increases. By reasonable is meant not very close to either 1 or 0. If P_1 is close to 1 then there is relative certainty that the most likely item meets user needs, so displaying additional items would not add much to P, and therefore monodisplay would be adequate. On the other hand P_n might be close to 0 for n greater than some value k, in which case a multidisplay of over k items would be little better than one of k items. When those extreme cases are not present, equation (1) implies that for low n (such as n=1, or monodisplay) increasing n by even a little makes a big difference in P, the chance that at least one displayed item will be of interest. Equation (1) also implies that the returns in terms of increased likelihood that at least one item is of interest diminish rapidly as n increases.

Example 1. Suppose P_1=0.4, P_2=0.35, P_3=0.3,…. Then by equation (1), increasing n from 1 to 2 increases the probability of an item being of interest from .4 to .61, over 50%, while increasing n from 6 to 7 has little to recommend it since this would only increase the probability of an item being of interest from .861 to .875, or just 1.6%.

As this example shows, the number of items that need to be displayed is not great for reasonable values of P_n. Perhaps an awareness of this analysis could lead search engines to improve the usefulness of their returned lists.

Other considerations. We have not discussed the issue of how much space is available for display of each item. Obviously, the more items displayed the less space is available for each. When this space is too small to display the interesting part of an item, or worse, enough of it to determine if it is in fact of interest, what is gained by displaying more items is lost by not displaying enough of each item, making the display an *in*direct multidisplay and leading to both the need for user interface actions to examine items more closely and the additional cognitive overhead of maintaining a sense of location and state while navigating.

One way to alleviate this problem is to be judicious about what in the item is displayed. For example the Google search engine displays only a phrase or so of each retrieved item, but these phrases are chosen for relevance to the query that retrieved them.

COMBINING MULTI-/MONODISPLAY AND DIRECT/INDIRECT DISPLAY

If we consider display approaches based on whether they use multidisplay or monodisplay, and whether they use direct or indirect display, there are four possible combinations.

Indirect monodisplay. Used in signaling readiness of a system and prompting for the relevant interaction, e.g., a popup display stating "press control-alt-delete to log in." (Even then, direct display of the login interaction display itself would be more convenient than requiring it to be explicitly invoked by pressing three buttons.)

Direct monodisplay. Used when a user wishes to interact with a given information item (e.g. editing a document).

Indirect multidisplay. Used when there are a number of abstractions of information items to display, such as a directory or a list of links.

Direct multidisplay. Useful when there is a limited number of items to display, and there is enough room to display them. Using a higher capacity display would allow more and larger items to be displayed. Fortunately display hardware is improving over time with higher resolutions and improved portability [17]. For example, electronic paper has recently been marketed and electronic wallpaper is becoming plausible as a future technology [8]. Trends in display hardware information presentation capacity are significant because even a modest %/year increase in capacity means that displays with several times the information presentation capacity of present displays will be available in the not-too-distant future.

Interface actions and cognitive overhead. An interesting and potentially significant application of direct multidisplay is to reduce the number of interface actions and other claims on cognitive overhead in certain situations. Actions such as moving and clicking a mouse take time and interrupt thought flow, and a multidisplay strategy requires fewer such actions than a monodisplay strategy. For example, in common Web search engines, viewing the contents of some URL in the list of URLs returned in response to a query requires (1) inferring about content from the items in the list, and (2) another click to view the item chosen. To view another item requires the same steps, preceded by another step, clicking the "back" button on the browser to return to the list. After viewing more than three or so items, returning to one that in retrospect needs to be viewed again requires remembering which it was, or worse, rechecking one or more to find it again. The need for such interface actions contributes to inefficiency, is likely to be annoying, and should be eliminated if possible.

DIRECT MULTIDISPLAY AND MULTIBROWSER

The system we have built, MultiBrowser, supports information foraging within hypermedia repositories. It takes as input either a search engine query or an HTML file containing links to URLs, and processes that material in two phases comprising several steps, as follows.

Phase 1: Document-Scale Processing

MultiBrowser retrieves the documents linked from the search engine return list or from the hyperlinks in the input file. Documents are clustered into three groups. We use the k-means algorithm, a standard clustering algorithm. The distance metric we use is the cosine measure in the space of strings of 5 characters, or 5-grams (Damashek 1995 [4]), a metric that has been shown to produce results competitive with other methods (Mayfield and McNamee 1998 [16]). The distances of each document to the centroids of the three clusters are used to compute intensities of red, green, and blue (RGB) components, which are combined into a color for labeling the document. This label is a horizontal color bar at the top of the subwindow displaying the document (Figure 1). The color bar summarizes the document in the sense that the user can visually compare the similarities of the documents in the different subwindows by comparing their color bars, in order to help decide which window to read next. Each color bar also contains a link that, when clicked, loads the corresponding document into the full browser frame (monodisplay) for a closer look.

Phase 2: Paragraph-Scale Processing

After a color bar has been computed for each document, the documents are segmented into paragraphs and the set of paragraphs is processed. As in the case of documents, each paragraph is mapped to a normalized point in 5-gram space, and points are compared using the cosine similarity measure mentioned earlier. For each paragraph, the five other most similar paragraphs are identified, regardless of what documents they are in, so that all six paragraphs can later be displayed simultaneously in the six subwindows in response to a user click on a "FIND SIMILAR" link (Figure 1).

After each paragraph a "FIND SIMILAR" link is inserted, and before it and an anchor (HTML <a name=…> tag) is inserted. Each "FIND SIMILAR" link points to a unique HTML file containing an HTML frameset tag with six subwindows, each showing content starting at an anchor inserted earlier. The top left subwindow shows content starting at the same paragraph whose "FIND SIMILAR" link was clicked, and the other five subwindows show content starting at each of the five paragraphs rated as most similar to the one whose "FIND SIMILAR" link was clicked. Thus each link in essence has six targets. Such multi-tailed links have been explored as early as the '80s (Stotts and Furuta 1989 [23]). Subwindows are scrollable, allowing them to contain the entire document whose paragraph they display.

At the top of each subwindow is the color bar computed for the document in that subwindow.

The system is designed to be accessed using a standard Web browser, so screen history navigation is supported. History navigation has been shown to be valuable (Catledge and Pitkow 1995 [3]; Tauscher and Greenberg 1997 [24]). Also, because each repository created by MultiBrowser constitutes a Web resource that is specially structured with links and files but has no CGI or other special server-side software, a repository once created can be hosted by a Web site easily and securely.

MultiBrowser repositories present information using direct multidisplay (direct display and multidisplay). The presence of several information items displayed simultaneously also means that sometimes more than one will be of interest, eliminating the need to navigate to another place in the repository in those cases. This is a kind of prefetch, and is examined next.

DIRECT MULTIDISPLAY AND PREFETCH

Supppose a system displays at least two items and, after the user views one, a second one will then be of interest. Call this a *prefetch,* because the second interesting item was displayed before the first was read. Prefetch can only occur when direct multidisplay is used, because monodisplay implies only showing one item at a time, and indirect display implies the need to explicitly fetch content from a hyperlink or other indirect display of it. We wish to characterize the likelihood of successful prefetch in a direct multidisplay.

Let n be the number of items in a multidisplay. Prefetch occurs when two things are true, i) some displayed item is of interest now, and ii) upon finishing with that item one of the remaining $n-1$ displayed items will be of interest.

Given some item currently of interest in a multidisplay, consider the most likely of the remaining $n-1$ items to be of interest next. Define P_1 as the probability that it will in fact be of interest. Similarly, define P_2 as the probability that the second most likely of the remaining items to be of interest next, will be, and define $P_3 \ldots P_{n-1}$ similarly. Then

$$P_{none} = p(\textit{none of the remaining } n-1 \textit{ items will be of interest next}) = (1-P_1)(1-P_2)(1-P_3)\ldots(1-P_{n-1}).$$

Therefore

$$p(\textit{prefetch occurs} \mid \textit{a first item is of interest}) = 1-P_{none} = 1-(1-P_1)(1-P_2)(1-P_3)\ldots(1-P_{n-1}) \qquad (2)$$

The last step in deriving a formula is to remove the given that a first item is of interest, and thus take into account the probability of that given, since without it prefetch will not occur. That value, defined in equation (1), is P. Then equation (2) will only apply in a proportion P of the cases:

$$p(\textit{prefetch occurs}) = P[1-(1-P_1)(1-P_2)(1-P_3)\ldots(1-P_{n-1})] \qquad (3)$$

Like for the discussion surrounding equation (1), under reasonable conditions increasing the value of n offers rapidly diminishing returns.

Example 2. Suppose P=0.861 (see *Example 1*). Suppose also that P_1=0.3, P_2=0.25, P_3=0.2,....
For n=2, $p(\textit{prefetch occurs})=0.861[1-(1-0.3)]=0.26$.
For n=3 however,
$p(\textit{prefetch occurs})=0.861[1-(1-0.3)(1-0.25)]=0.41$.
This is a significant improvement of 58%. By comparison, the improvement from increasing n from 6 to 7 is only 2.4%.

Since increasing n to high values will usually not result in much improvement, even a lengthy list of links, using indirect display to cram as many as possible onto a screen, would likely have only incremental benefit and even then the prefetch is quite incomplete since only links, not content, are presented.

EXPERIMENTS

Various user studies have been done in the past on collage-based systems such as those cited earlier. We supplement those with an experiment using MultiBrowser specifically, and another experiment concerning the color bars visualization MultiBrowser uses.

Design of Experiment 1

Six volunteers participated. Four were graduate students from various University departments and two were professionals working locally. None had any experience with MultiBrowser.

In Experiment 1, subjects were offered the choice of browsing either a Multi-Browser repository on powered parachuting or one on vegetarian cooking. Each was asked to spend a few minutes browsing at their leisure after a short training session. Then they wrote answers to questions on their perceptions of Multi-Browser. They then were asked to find some specific items of information in the repository in an information retrieval task. The average post-training time for the experiment was 26.7 minutes.

Results: Experiment 1

Table 2 analyzes responses to question 1, regarding the density of information displayed in MultiBrowser. All felt the density was high.

Density of information	# of votes
Above normal	2
Too high	2
Acceptably high	2
Below normal	0
Too low	0
No comment	0

Table 2. Analysis of responses to the request, "Comment on the density of relevant information appearing, on average, on the screen when MultiBrowser is used vs. when ordinary display is used."

Table 3 shows the results of answers to question 2, regarding the efficiency of finding relevant information with MultiDisplay. All the subjects felt that MultiBrowser is efficient in finding relevant information. This is despite the fact that average performance on information retrieval tasks was not improved (unsurprisingly since the purpose of the Multi-Browser system is to support information foraging rather than information retrieval).

Efficiency	# of votes
Above normal	2
High efficiency	2
Efficient	2
Low efficiency	0
Below normal	0
No comment	0

Table 3. Analysis of responses to the request, "Comment on the efficiency of finding relevant information using 'Find Similar' links."

Table 4 shows the results of answers to question 3, regarding the 6 sub-frame display style. Though subjects had different opinions, four out of six preferred multiple sub-frames (4 or 6) on the screen.

Display	# of votes
Like 6 sub-frames	2
Neutral	2
4 sub-frames is better	2

Table 4. Analysis of responses to the request, "Comment on the style of information display with 6 sub-frames appearing in the main window."

Design of Experiment 2

The subjects in Experiment 1 also participated in Experiment 2, which was designed to compare users' judgements of document similarities based on color bars with their judgements based on lists consisting of document titles, each paired with a brief initial passage from the document (the way many Web search engines respond).

Two sets of six documents were identified from two typical MultiBrowser screens, one (Version A) from the powered parachuting repository, and the other (Version B) from the vegetarian cooking repository. For the color comparison task, all document content was removed, leaving only the color bars. For each resulting sub-window in turn, subjects were asked which two other sub-windows had color bars most similar in color to that of the given sub-window. For the title+passage comparison task, the Alta Vista listings of the same six documents were presented. For each document in the list, subjects were asked which two other documents in the list seemed most similar to the given document. Subjects were not told that the same six documents were used for both the color and title+passage tasks.

Results: Experiment 2

Subjects averaged 1.2 minutes in completing the color comparison task, nearly 3 times faster than their average of 3.5 minutes for the title+passage comparison task. The slowest subject's color task time was shorter than the fastest subject's title+passage task time, showing that color comparisons are significantly faster ($p<0.0005$).

To compare the quality of judgements elicited by the two comparison tasks we defined *consistency ratio* as the fraction of comparison judgements from one subject and task that agreed with judgements from another subject or task. For task agreement, the consistency ratio of the two tasks for a given subject, averaged over all the subjects, was only 0.24 out of a possible 1. Apparently the color bars yielded similarity judgements surprisingly different from those yielded by the title+passage descriptions.

With such a low consistency between the two tasks, an important question is which better supports similarity judgements among documents in a set. One way to explore this is to compare the similarity judgements of different subjects, because if subjects tend to agree in their similarity judgements on one task more than on another, then the lower-consistency task is comparatively deficient. Results of this comparison are shown in Table 5. Statistical analysis of that table is hampered by the presence of dependencies among the columns because every subject influences two columns. Nevertheless the consistency figures clearly are considerably higher for the color task than for the title+passage task. This suggests that MultiBrowser's color bar technique has advantages that might be exploited, for example, in search engine return lists.

Experiment:	Version A			Version B		
Subjects:	1&2	2&3	3&1	4&5	5&6	6&4
Color task:	0.75	0.67	0.58	0.83	0.75	0.75
Title+Passage:	0.33	0.33	0.4	0	0.36	0.36

Table 5. Consistency ratios among the 3 pairs of subjects in each of experiment versions A and B. Similarity judgements from different subjects had considerably higher consistency in the color task than in the title+passage task. Even the lowest between-subject consistency in the color task was higher than the highest in the title+passage task.

NEXT STEPS

Interactive systems can benefit from an internal model of the user to help the system optimize its interactions to the user. Such models often contain [14]:

- the goals of the user;
- the ways the user wishes to achieve these goals; and
- the knowledge that the user has about the domain.

We plan to generate user profiles based on characteristics such as age, career, and other characteristics elicited through a check-box style questionnaire. Only those Web documents meeting a minimum threshold of relevance to the user's provile will be processed into the MultiBrowser repository. The same idea could be applied to apply to on-line help systems or to browsing an e-book or other long digital document.

We also plan a number of other improvements to further support information foraging in MultiBrowser. Based on user experiment 1 we will improve windowing flexibility. One strategy for this is a "peek" toggle (Kamba et al. 1995 [11]) to expand a given subwindow to fill the entire available space. Another is to allow users to compose the set of subwindows in whole or in part, by allowing particularly interesting subwindows to be "locked" so that when the display is updated that subwindow will remain unchanged.

DISCUSSION AND CONCLUSION

We have focused on three closely connected topics, (1) an exploration of direct multidisplay, (2) MultiBrowser, a browsing system that supports information foraging, and (3) a visualization technique used in MultiBrowser that expresses similarities among documents.

Direct multidisplay was identified as a design criterion likely to be increasingly useful as display technology continues to improve. The formalization could be augmented by taking into account additional factors. For example a more elaborate formalization that generalizes the analysis surrounding equation (1) to include the relationship between size of display area and probability that the user can tell if a displayed item is of interest would be interesting. Another augmentation would address the implicit assumption that the probabilities that subwindows are of interest are independent, since it is reasonable to suggest exploring the effects of relaxing this assumption. Analogous limitations and caveats arise with user studies, because it can be a challenge to assess the degree to which results can be generalized. Generalization requires ignoring the influence on the results of aspects of the experimental that are assumed to be insignificant. Most, such as the weather and innumerable other factors, probably are. Others might not be. Though not infallible, user studies and formalizations can both be useful.

MultiBrowser was developed to demonstrate direct multidisplay as a design criterion. A number of other direct multidisplay systems have been reported over the years. MultiBrowser further explores that design space, as well as serving as a contemporary implementation and testbed that supports code modification needs as they arise. MultiBrowser is intended to support information foraging in contrast to a traditional information retrieval interaction model that iterates a process of querying and reviewing returned material until a goal is reached (Shneiderman et al. 1998 [22]; Hearst 1999 [7]). *Berry-picking* (reviewed by Hearst 1999, Sec. 10.3.1 [7]) and *information foraging* (Pirolli and Card 1995 [19]; Pirolli 1998 [20]; Wexelblatt and Maes 1999 [25]) refer to the less directed kind of browsing addressed here. Foraging is an appropriate model of behavior when goals are vague, a situation that often occurs in practice, as when one "surfs" the Web with a "browser," "skims" a book, or "browses" library shelves. Such terms are suggestive of information foraging and, more generally, the limitations of a restrictive concept of goal during information acquisition.

A notable design feature MultiBrowser is the use of color bars. Color bars were found to support similarity judgements among documents faster and with better consistency than the traditional title+passage excerpts typically provided by search engines. This suggests using color tags to supplement title+passage information in search engine return lists. To save space, small squares could serve the same purpose as the wider bars in MultiBrowser. Even if adding color tags took enough to require reducing the number of items in the return list to compensate, equations 1 and 3 suggest that this would be acceptable.

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