COORDINATING INFORMATION-SEEKING ON INTERACTIVE DISPLAYS

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ABSTRACT
Effective information-seeking in an electronic library, offering a large multi-use information space of materials and services, requires the searcher to coordinate his or her reading, information-seeking, and writing activities. Most interactive displays, however, do not help people monitor their problem solving. If they did, a major barrier confronting searchers would be lowered. Rationale for this claim is presented and an interactive display for exploring its consequences is introduced. The display, called SketchTrieve, stresses ‘ease of expression’ above all other design options, and it gives prominence to information-seeking ‘material’, rather than ‘retrieval controls’.

INTRODUCTION
A room containing reference books, primary sources, indexing and abstracting systems, journals, and a couple of large tables is one reader-centred view of a library. The ordinariness of this view belies the complexity of interaction that usually ensues when readers make use of library materials. In the business of electronic libraries, a central problem is how to embed that room on the computer desktop, so that people can, with pleasure, read and seek information, while at the same time analyse, write, tabulate and draw - in short, solve their problems.

We shall consider one ingredient of the solution: displays that allow readers to coordinate their work. By coordination we mean managing the dependencies among activities. Even if we shrink that room to a lone table and textbook there is still a wide range of bookish pursuits that readers may need to coordinate.

CLAIM: COORDINATION DIFFICULTIES LIMIT INFORMATION-SEEKING PERFORMANCE
Sonya Symons and Michael Presselley studied how university students extract information from textbooks. They gave students taking Introductory Psychology a basic textbook, which was unfamiliar to them, and challenged them with questions like “What theory accounts for why people remember high imagery words better than low imagery words?”.

They report that to answer this question, one student:

... first searched the index for the term imagery. He then inspected a page of text in the first chapter where different areas of psychology are introduced... The student then returned to the index for references to imagery before inspecting the section “Visual thinking”... He then returned to the index to
find another reference... before inspecting a vignette on the relation between mental imagery and perception. The student returned to the index and then inspected the first 10 pages of the chapter on perception before running out of time without finding the answer to the question. (op. cit., p. 258)

Even this most basic series of actions requires coordination: switch to page 205, switch to chapter 4, switch to the index, recall if this part of the book has been visited before. Other students showed more varied access patterns where they skimmed pages, scanned the table of contents, and consulted the index. As the complexity of the material and the uncertainty of one’s information need increases so too does the importance and difficulty of coordination. Consider, for example, task-defer-subtask episodes, where a reader scans sections but defers close scrutiny of some of them until later, or where a reader plans to follow up leads: authors for reference searches, papers for citation searches, topics for browsing in Britannica’s Propaedia, words which may be good descriptors in another document collection. Marcia Bates7 discusses many such shifts in search activity, introducing the ‘berrypicking’ metaphor to denote the opportunistic character of problem solving; going beyond ‘search’ and ‘selection’, Vicki O’Day and Robin Jeffries5 report that the interconnectiveness of search episodes is often directed by analysis and processing of retrieved information, elaborating the metaphor to that of searchers “making berry desert (sometimes with surprising ingredients)” (p. 441); and Patricia Wright6 marshals empirical work which shows that well-designed displays can raise a reader’s willingness to explore in depth and shift focus.

Coordination in reading and information-seeking comes in many guises. For example, when electronic libraries take on some of the mechanical work of using books, readers are freed to work on other tasks while waiting for information to be delivered. Asynchrony, though, complicates reader coordination. One example is word translation. In Perseus, a hypermedia system of ancient Greece, readers can translate a Greek word into a set of English word forms automatically but because of the complexity of Greek morphology this process can take between 30-60 seconds. During this translation time, students were observed to read on, then, once the translation became available, switch back to the point where the unknown word was first encountered.

Figure 1 represents this reading episode as a set of tasks, conditions which spawn subtasks, and conditions which lead to backtracking. Although the example is for on-line dictionary consultation, it could be abstracted into a rather general schema that represents much of the structure of the task-defer-subtask episodes. A lead, for example, could spawn a subtask or become a point to be backtracked to. Note also that the points for backtracking could just as easily be points for recursively spawning subgoals, making the job of coordination all the more difficult. The question we ask is: how might interactive displays help information-seekers coordinate the spawning of sub-tasks and backtracking to previously deferred work?
Marcia Bates\textsuperscript{4} reviews the information search tactics available to readers and discusses the importance of monitoring tactics, namely those tasks that help to keep the search on track and efficient. She divides monitoring tactics into five types:

- 1) Check - Comparing the original information need or request with the current state or topic of a search;
- 2) Weight - Deciding which of several options will be the most productive;
- 3) Pattern - Recognising, describing, and examining search patterns which have proven successful in the past for certain types of queries;
- 4) Correct - Being vigilant to spelling and factual errors;
- 5) Record - Keeping track of the trails one has followed and would like to follow in the future. Monitoring tasks can be troublesome. Bates cites a 1964 report by Carlson:

[Librarians] are not consistent in recording what they find or what they intend to check later. In many cases, the human will find cross references and state that they will check these cross references later. Unless they make some written note, they never seem to check them. Each librarian studied, at some time during the search, noticed some discrepancy either in an item being scanned, or in an item recorded as acceptable, and made the verbal comment that he would check this later. Once again they almost never made a written note about this and when they did not write a note, they never did check the item ... (op. cit., p. 209) [emphasis added]

The crucial thing about coordination is not so much the precise activities and dependencies - assume there is a complex, changing network. Rather, what is important is the extent to which a display allows people to track their activities fluidly, without devoting too much attention to this ongoing job. To use the language of Donald Schön\textsuperscript{8}, displays should ‘talk back’ and allow people to
‘reflect-in-action’ about what they’ve done, what they still need to do, and, for example, what work is ongoing, provisional, and completed.

CLAIM: KEYHOLE VIEWS HAMPER COORDINATION

How then might displays for information-seeking help people coordinate their work? The basic questions are how easy is it to: jot down ideas, organise them spatially, compare two or more chunks of material side-by-side, and annotate what’s been done. Inspection of many user interfaces for information-seeking shows that these most elementary tasks, needed in any problem solving situation, are difficult, or indeed impossible, to carry out on the displays provided. Consider, for example, the simple (or is it complex?) problem of formulating a query, ignoring the results generated by it. A typical interface offers a single input field (A) or template for words associated with different attributes (B):

![Image of a search interface with fields for search, author, title, and keywords]

What can one do with such displays? Certainly, they provide little opportunity for exploring one’s information need. It is, for example, impossible to first ‘brainstorm’ and ‘jot’ down a bunch of different words, ‘organise’ them into categories or ‘list’ them from most to least important, and then systematically submit combinations of words for retrieving documents. The keyhole view of the query provides no opportunity for ‘documenting’ work and it provides no information on the history of queries submitted. One can not even ‘compare’ two different queries. On the whole, these simple tasks are not well supported in many interfaces for information-seeking.

In studies of design process, and particularly computer programming, the emerging consensus seems to be that computerised design environments must support these elementary tasks (see Willemien Visser’s review[16]). However, researchers in information retrieval seem to not yet have arrived at this conclusion, despite their willingness to characterise information-seeking as a wickedly difficult problem. This is surprising! - ‘design’ and ‘information-seeking’ have much in common.

Debora Shaw[11], in a review of user interfaces for information retrieval, reports that “The less efficient searchers are more likely to become confused by the different possibilities, forget information retrieved, and repeat searches” and concludes that a key problem is “how interface design can decrease stress or provide support?” (p. 166). Those ‘searchers’ were showing the classic symptoms of working memory failure, and we speculate that they are ‘less efficient’ because 1) they lack the experience to know when certain information must be remembered and, moreover, in the urgency of completing immediate goals tend to not keep a record of it in any case; and 2) the displays they use do not capture a trace of work done. Recall, though, that even librarians, professional searchers, tend to forget important aspects of their search activity (Carlson, cited above by Bates).

We believe that the answer to Shaw’s question is to provide a very informal display which, like paper and pencil, allows one to easily externalise working memory about immediate and deferred goals. Such a display would capture odds and ends about search activity naturally during the course of work. Then, the display
becomes an aide-mémoire for later reflection. In the library room, the aide-
mémoire is a large three dimensional visual field: the table, the scraps of paper and
bookmarks, opened pages and propped books, index cards, and small piles of books
scattered round. An equivalent flotsam and jetsam is needed in the electronic
library.

SKETCHTRIEVE - A DISPLAY FOR COORDINATED
INFORMATION-SEEKING BY SKETCHING

We, and our research collaborators12, are implementing C++ class hierarchies for
representing the major abstractions of Information Retrieval13. The code
frameworks speed IR application development through software-reuse. We are
implementing both a back-end framework for storing, indexing, and retrieving
documents, or indeed general ‘information objects’, and a front-end framework for
building user interfaces. A major design goal for the front-end framework is to
provide an architecture for unifying a variety of information retrieval methods,
common place techniques like Boolean and best-match search, but also new
innovative techniques for visualising information spaces. An important technical
question is how IR services can be incorporated into the future computer desktop of
interoperable ‘documents’ and ‘applications’.

If a major barrier confronting the information-seeker is coordination difficulty, then
what sort of interface - not the details, but the coarse-grain, structural properties -
might be most helpful? The design inspiration we are pursuing is that people need
displays that allow them to sketch, by which is meant not ‘drawing’, but rather
‘ease of expression’. In many areas of problem solving, sketching plays a crucial
role, especially in the early stages of work (e.g., physics problem solving14,
typographic design15, writing16). Speaking as an architect, Donald Schön17 puts it this
way:

The act of drawing can be rapid and spontaneous, but the residual traces are
stable.... No move is irreversible. The designer can try, look, and by shifting
to another sheet of paper, try again. As a consequence, he can perform
learning sequences in which he corrects his errors and takes account of
previously unanticipated results of his moves. (pp 157-158)

A informal display which allows people to explore their information needs by trial-
and-error and which captures odds and ends of this opportunistic, yet progressive,
activity appears to be exactly what is needed to support the monitoring tasks given
by Bates and the backtracking shown in figure 1. From an intuitive stance, we
reason that if that a large whiteboard and a couple of coloured markers is a pretty
good device for outlining the structure of a report, then a similar fluid
computational display might help information seekers. Certainly, we are
encouraged by the spreadsheet when used to capture ideas quickly17.

SketchTrieve is an initial response to the claim. The heart of the design is a very
simple graphic-editor, where the ‘material’ of information-seeking is given
prominence and the retrieval services lie ready in the background. Figure 2 shows a
mock-up.
SketchTrieve offers two types of component: stickies and services. A service is a representation of some retrieval machinery, and provides a dialogue for controlling how the machinery interprets queries. In figure 2, one service is a dictionary of scientific terms, another is an archive of noteworthy search episodes - this searcher likes to reuse his work. The third service is a commercial database that contains references to material on the petroleum industry. Services are added to the display and customised with the Service menu. As in a word processor's style-sheet, a service can be given perceptual features (e.g., font style, colour, and weight). This is a simple application of what Thomas Green calls the 'description level', where elements of a searcher's problem domain can be coded perceptually on the display, and thereby help him or her map domain problems to-and-from the computer.

Stickies, a term borrowed from the Macintosh, are for representing information-seeking material, including queries, results, notes on information needs, document views, etc. Stickies can be used as a container, but more often they are dynamic. They could provide, for example, a syntax directed editor to help users with a retrieval notation, or a spell-checker, or selection boxes for indicating which documents in a result list are more relevant - a requirement for services which accept relevance feedback. In figure 2, three types of stickies have been used: 'comment', the words typed directly onto the display; 'plain', the words in the rectangle; and 'query' the structured query in the bottom-right of the display. As with services, a menu is provided for creating and customising them.

Stickies can be dragged-and-dropped onto services, causing the service to interpret the contents of the sticky and to produce some results, which are then attached to the sticky. For example, in figure 2, it can be seen that the science dictionary has attached the definition of 'latex' and 'emulsion' to a sticky. When the user drops the sticky containing the phrase 'paint market' onto the service called 'previous...
work’ a list of old search episodes will be attached to the sticky. The third service will generate a list of publications when the structured query is dropped onto it.

That is SketchTrieve. It is simple, but even so a searcher can:

*Brainstorm.* He can click and type words, notes, or annotations directly on the display.

*Organise.* He can arrange stickies and services to show work-plans, -roles, and -flow.

*Compare.* He can position two stickies or services, open them up, and look at them side-by-side.

*Document.* He can code his problem domain with perceptual cues (stickies and services have styles).

*Multi-task.* He can access several types of IR services, and indeed specialised results viewers, on the same display.

*Abstract.* He can find stickies (or services) by name and change the attributes of all instances of a particular type (because styles are named).

*Cooperate.* He can exchange SketchTrieve documents with his colleagues.

Most importantly, with these basic tasks well-supported, the searcher can coordinate his work by letting the display preserve odds and ends about what he has done and still intends to do. Even glancing at figure 2 shows a plan of action, where three search tasks are on the go and two have yet to be issued, namely those stickies that are to the top-left of their respective services. Though not shown, stickies can be copied and pasted to record stages of work or points where subgoals were spawned, and to thus signal points to back-track to. Of course, the searcher can always clear away parts of the display.

At present, we are fleshing out the design space and implementing SketchTrieve. We expect it to change in detail - a box-and-line data flow notation may prove superior to drag-and-drop. In basic style, however, SketchTrieve will change little, at least until we observe how people use it.

**CONCLUSION**

In a user-interface for information-seeking, if there is one property, among all competitors, to optimise it is ‘ease of expression’. SketchTrieve allows us to test this claim, and to learn about the inevitable trade-offs at this position of the design space. It is a display that gives searchers much flexibility for organising the structure of search episodes, for keeping track of plans, for reconsidering old decisions, for checking progress towards a goal. SketchTrieve imposes very few constraints on how people ‘should’ seek information. This is the exact opposite of most user-interfaces for IR, which are formal, overly ‘determined’ devices. The results of this research will allow us to: 1) better understand the coordination needs of information seekers; and 2) discover how those needs can be best supported on interactive displays.

SketchTrieve raises a number of problems, as new ideas should. One, this paper has taken a fairly narrow view of coordination, namely that of ‘monitoring’ search progress and managing goals. ‘Handling’, the time to convert material in a source
form to a target form, is another sort of coordination task. If you've heard that a relevant document exists at an Australian Internet site, but your connection is very slow, and the document is written in Fijian, which you don't speak, and is marked-up in troff, which requires a visit to the help desk, then it will have to be a very important document indeed before you will be willing to deal with it. Very often search material is in one form, but getting it into another form is too time-consuming with the traditional ‘monolithic’ IR services; therefore, avenues for information-seeking are abandoned, which, given low handling costs, would otherwise be pursued. Pamela Sandstrom discusses a ‘foraging’ theory where, to put it very roughly, searchers attempt to optimise ‘search’ effort for ‘handling’ effort\(^9\). If handling effort were reduced there would be more time to search. This is exactly what SketchTrieve should do because various elements of IR machinery can be unified on its display.

Two, this paper has said little about the ‘sufficiency of expression’. How many kinds of IR services can be represented in SketchTrieve? Exploration of a half dozen Scenarios of Use leads us to believe that yes, indeed, many services and specialised viewers can be represented. The proof, though, will have to wait until we observe how people use the system we build.

Three, as described, SketchTrieve would not help with the coordination troubles faced by the students who had to find relevant sections in a textbook in Symons and Pressley’s experiment\(^8\). To be of any help, SketchTrieve would have to have an effective coupling between ‘content’ view of the textbook and the ‘summary’ view, say an index, shown in SketchTrieve. So, for example, as one visited sections in the textbook, these would be shown visually in the index. SketchTrieve must be compatible with target application viewers.

Four, nothing has been said about control of layout. As searchers follow leads, brainstorm, compare pieces of material, and so on, the display will become messy. That is good during exploratory work because the mess reveals a trace of what has been done. However, at some point, the information seeker will need to step back and rationalise, organise the display, and document it for future reference or for colleagues. These tasks require a grouping mechanism and control over layout.

The results of this research will inform us as to what information-seekers need from an interactive display so that they can coordinate their problem solving. SketchTrieve is a design vision. Though it lacks detail, there is little doubt that ‘coordination’ difficulties limit performance in information-seeking. ‘Ease of expression’ is crucial and it is SketchTrieve’s major virtue.

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