Developing a Multimedia Browsing System based on Cohesion

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Abstract.

The goal of our project was to design and test a multimedia browsing system whose information is organized by cohesive elements. Cohesive elements in a text are key ideas in the text that are referred to again and again, and which form a main topic in the discourse. In our system, a user was able to browse a database of multimedia information by following key ideas along their cohesion paths. The cohesive elements, and the items selected as instances for each cohesive element, were chosen by the developer (or author) of the system, and not by the user.

The browser we built had two components. First was an authoring tool, which allowed the author to create a multimedia presentation. Second was a browser, which allowed the user to browse through the material, following cohesive paths. We built several different browsers, and ran experiments to analyze users' behavior as they used two of the browsers. We will briefly describe the authoring tool and browser, and then we will describe the actual implementations and testing. Finally, we will draw conclusions about our design and make suggestions about the next generation of such a system.

(Discussions of other approaches to multimedia browsing can be found in Bieber & Isakowitz (1995); Blackmore (1993); Garzotto, Mainetti, & Paolini (1996); Hirashima, Hachiya, Kashihara, & Toyoda (1997); Losee (1997); McDonald & Stevenson (1998); Nielsen (1990); So, Ahmad, & Karlapalem (1998); Stotts & Furuta (1990); and Tsirikos, Markousis, Mouroulis, & Hatzopoulos, M. (1999).)

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1. A "subway" model of cohesion.

1.1 Authoring tool.

An author could make a multimedia presentation by creating a data structure that was a cohesion-based graph. He or she could also analyze the graph built thus far. In constructing a graph, the author had 3 tasks:

(1) assign the materials to be browsed to individual nodes;
(2) decide on cohesive elements among nodes; and
(3) establish the order of nodes within each cohesive path.

The authoring tool provided this functionality.

The author could also perform several operations which allowed him or her to determine some graph-theoretical properties of the current graph.

1.2 Browser.

The product of the authoring process was a completed presentation. This presentation was input to the browser, allowing the learner to traverse the graph and browse the materials it contained. The user of the browser traversed the material by using one of the cohesive paths (which we call lines, for "subway lines"), and changed paths at intersections. (Following the metaphor of subway lines, we call the nodes of the graph stations.)

1.3 Implementations.

1.3.1 One implementation of the authoring tool was used in designing some (but not all) versions of the browsers. Two of the browsers, described below, were used for testing subjects. Our platform was a Power Macintosh 8500/120.

1.3.2 Choice of multimedia materials.

We selected birds of the world for our multimedia materials. First, we found such materials were available in electronic format; and second, information about birds has a natural cohesive structure. For example, field guides in book form group birds by geographic region, size, habitat, etc. Within each such group in a field guide, similar birds are next to each other, so a person can choose a habitat based on some information and browse through the book until he or she finds the right match.

We found that sounds of bird calls were also electronically available, and they are included in our implementations, which were titled All about birds.

1.3.3 The first browser we tested.

The first testable system, All About Birds, can be seen at http://www.math.nmsu.edu/~eovaska/HTML.v3/birds.html. The cohesive paths used in this implementation were birds themselves (47) and features such as size, diet, range, and habitat. The total number of nodes (stations) was 425 . The stations contained multimedia information: texts, pictures, and audio.

To test the first browser we collected data from twenty-two users on their ability to work with the implementation, and on their evaluation of it. (They were given questions to answer, such as: What color(s) is the female bobwhite? Name some birds that make nests on the ground. Find out as much as you can about a particular bird that interests you the most. Describe its characteristics (e.g., appearance, call, habitat, feeding habits, etc.) (The full questionnaire is included in the Appendix.)

Users of the system had no trouble finding relevant information and answers to the questions. They liked the system and found it easy to use. Here are a few examples of comments:

It took a few tries to get used to the set up. Great though!

It was pretty easy to figure out where to go.

I liked the groupings of scientific order, diet, range, and habitat. Images are nice.

I liked how I could link w/other birds w/similar characteristics.

Lots of information; carefully outlined.

Good, logical organization of material and links

I liked the fact that you can go to another bird of a specific trait, like region, size, order, and so on.

1.3.4 The second browser we tested.

The second testable browser can be seen at http://math.nmsu.edu/~kavilla/version4/birds.html.

The second browser differed in several aspects from the first one. The cohesive lines were differently chosen, and the user interface was significantly changed. The graph had less nodes with more information in each node (the user had to scroll to see it all), and users worked with three windows instead of one.

We tested the browser with twenty-three users, giving them the same tasks and asking for the same kind of evaluation as before. They did not have any difficulty finding the needed information, but they did not like the changes we made in the interface.

Some comments made by users:
It took me a while to figure out what the subways did.

I did not like having to scroll so much.

I would have a menu where I'd be able to choose a specific bird or any other feature.

I had to use trial and error a lot due to lack of diverse subdirectories.

1.4 Conclusions about testing.

Most subjects using each browser did their tasks correctly and without much difficulty.
Their overall evaluation of the system was positive.
Their criticism centered on two aspects of the design:
(a) Details of the interface.
(b) The lack of "standard" search tools, such as menus and keyword searches, and the lack of a general description of the system's organization (the lack of a "map of the subway system").

(a) This criticism was often well justified, but it also indicated that most subjects who are experienced computer users strongly favor the screen display that they are most familiar with. This last element has to be given a higher priority in any future design. The interface should be "as standard as possible."

(b) We introduced these "omissions" on purpose. We wanted to know if just traversals alone, through the predetermined paths that the system offers, are sufficient for doing a whole variety of tasks, independent of the possibility that some other mechanisms such as keyword searches may be more efficient in some situations (such as searching through long texts).

*** The answer to our question is positive; the subway schema may be
*** used as the sole search mechanism.

We also wanted to know if users would get lost or confused since they couldn't see the overall organization of the data.

*** Users do not get lost or confused without a "map of the system", but
*** they want to have such maps available.

2. Conclusions about the design.

2.1 Drawbacks of the existing design.

2.1.1 Central station.

Users always wanted to have a "home station", namely, a location they could always return to. In the present design this was achieved by creating a "central station", namely, one location that is common to all the lines. This solution did not create any problems because our system was rather small. But we know that it would create a problem if the system were expanded.

Let's call any station that has many lines passing through it (let's say 10 or more) a hub. A hub with up to 40 lines is quite manageable, but growth above this limit makes its use more and more difficult. If a hub has more than 80 lines, it must have its own internal structure, search engine, and so on. And its complexity must grow with the growth of the system. So creating subsidiary hubs and forming a distributed set of centers appears to be a better solution for handling growth.

2.1.2 Location of menus and other general information.

"Subway lines" were not meant to be the only way a user could access information; they were meant to be used together with other techniques such as menus. But combining subways with menus presents one serious problem. Menus are static concepts. They are located somewhere, and they allow the user to access some information and come back to where he or she was. But in the subway system, the user is moving freely, and rarely comes back until the task is finished. Placing a menu at a single station makes the menu unavailable most of the time, and putting it everywhere is hardly feasible. This suggests that the system should be able to accommodate two kinds of information: static information, located at the stations, and portable information, which travels with the user.

A discussion about how these two problem can be handled is given in the next paragraph.

2.2 The next generation of browsers.

2.2.1 What can be included?

The idea behind the multimedia browser was that it provides uniform (logical) access to heterogeneous information. The information comes not just from different media, but it can also come from different data representations, which can be distributed in different environments, e.g., web pages, ASCII text files, Macintosh text files, and so on. Menus are the main method used to access such diverse data.

2.2.2 A change in point of view: A subway line as a menu.
A cyclic menu can be associated with each subway line; the menu can list all stations on that line, with one station, which is designated as "home", marked by the name of the line, and one station highlighted as being "currently visited". The user sees this menu all the time that he or she is on this line.

Example.

```
...
Australia
North America
South America <==        (The user is now on this station.)
Pacific Islands
*REGIONS*                (The home station, and the name of the line.)
East Africa
Antarctica
Southern Asia
...
```

Here the next station is Pacific Islands, and the previous station is North America. The menu can be of any length, and a reasonably long segment can be shown to the user. The user may go forward or backward, scroll the menu, and jump to station of his or her choice.

Each station also has its own menu in a similar format . This menu lists all the lines that pass through the station, with one line being a "main road" or a "postal address" for the station. The user sees this menu when he or she is at the station. The current line is highlighted.

Example (station = South America).

```
...
GEOGRAPHY
*CONTINENTS*      (The main road is CONTINENTS.)
CLIMATE
REGIONS <==       (The visitor is on the line REGIONS.)
CULTURE
ECONOMY
NATIONALITIES
...
```

If the user chooses a line, for example, the line CULTURE, it becomes highlighted, and the current subway menu, REGIONS, is replaced by the menu CULTURE, which the user "carries" with him or her until the next change of subway lines.

Thus, the subway menus list the stations, and the station menus list the lines. The home station plays a dual role and can be on both menus. The station menus are static and bound to a station. But the subway menus are "picked up", "carried", and "dropped" by the user.

2.2.3 A hierarchy of lines.
We call LINE2 a subsidiary of LINE1 if LINE1 is the main road passing through the home station on LINE2. We will require that the relationship of being a subsidiary must be acyclic; this makes a hierarchy of lines, with one or more "top level" lines. This hierarchy can be scaled up or down by using the menus described above, so it does not require any additional search tools.

In the next section we describe how this design addresses the problems of the current design.

2.3 Solution to the problems in the current design.

2.3.1 A crowded central station.
In the proposed design, the central station is simply the home station of the top level line. The stations of the top level line would be (mainly) the home stations of the next (second) level lines.

(a) The length of the line through the central station is less important, and also less a limiting factor, than the number of lines passing through a hub.

(b) The length of the line through the central station can also be easily controlled by creating new lines at lower levels, e.g., the third level, the fourth, and so on.

This solution does not put any restriction on the freedom to create arbitrary lines, because even the lowest level line may pass through any station, including the home station of the top level line.

2.3.2 Menus and the location of general information.
(a) Any hierarchical menu can be simulated by lines according to the schema shown below by an example.

Menu M.

Top level choices:	Second level choices:	Stations:
A	a	1, 2, 3, 4
	b	5, 6, 7
	c	8, 9, 10
B		11, 12, 13, 14, 15, (no second level choices)
C	d	1, 5, 8, 11 (the same station may be
	e	2, 6, 9, 10 listed several times)

Homes M, A, B, C, a, b, c, d, and e, can be created for new lines M, A, B, C, a, b, c, d, and e; they can be constructed as follows:

Line:	Its stations:	
M	M, A, B, C,	where lines A, B, C are subsidiaries of M.
A	A, a, b, c,	where lines a, b, c are subsidiaries of A.
B	B, 11, 12, 13, 14, 15	
C	C, d, e,	where lines d, e are subsidiaries of C.
a	a, 1, 2, 3, 4	
b	b, 5, 6, 7	
c	c, 8, 9, 10	
d	d, 1, 5, 8, 11	
e	e, 2, 6, 9, 10	

Choosing menu items is the same as moving from a line to its subsidiaries, or to its stations.

Thus the menus are not a new tool for accessing data; they are simply groups of lines organized in a rather rigid way.

(b) The location of "maps" and "directories."
With a given line L, we can associate all its subsidiary lines, subsidiaries of its subsidiaries, and so on, and finally, all the stations that are on these lines. A description of this graph can be viewed as a "road map" associated with L. Such a road map, which can be more or less detailed, together with lists of locations that are on it, will be kept at station L (which is the home of line L). Thus any information that the user may want to know when he or she is on a given line and which is not contained in the subway menu that he or she is carrying, will be kept at the home station of this line.

Keeping such information is the main reason for having a home station on each line.

A possible metaphor is a traveler who carries an AAA guide (a line menu), and uses local road signs (station menus), but also stops at visitors' centers (home stations) to get information about the area.

2.4 Future research.

The implementation of the next generation system described above will provide the user with:

(a) More versatile and powerful access to information.
(b) Information about the system and its properties.
(c) An interface that is more standard and simpler.

So there is essentially no doubt that the new system would perform as well as or better than the existing one.

Several properties of this system can also be predicted theoretically, because there is a rather simple theoretical model for it that is based on the well understood properties of bipartite graphs (see for example Wang, 1993).

The main question is, how would it scale up?
Our implementations had hundreds of nodes and tens of lines. Theoretically the new system can be expanded indefinitely without creating any bottle neck. But what is the limit imposed by a user's ability to browse through a very large amount of heterogeneous data? What factors determine such a limit? In order to answer these questions, we would need an implementation that has:

(a) Several thousand nodes.
(b) Several hundred lines.
(c) Around ten different topics, only partially related to each other.

3. Bibliography.

Baggett, P., Ehrenfeucht, A., Jungbauer, J., & Villaverde, K. (1998). Designing and testing a multimedia browsing system based on cohesion. Proceedings of the IASTED International Conference, Computers and Advanced Technology in Education, J. Gil-Mendieta & M. H. Hamza (Eds.) Anaheim: IASTED/ACTA Press, 9-12. (A talk with this same title was given by Baggett at CATE '98 (Computers and Advanced Technology in Education), Maty 27-30, 1998, Cancun, Mexico.)

Bieber, M. & Isakowitz, T. (Eds.) (1995). Designing hypermedia applications. Special issue of the Communications of the ACM 38(8).

Blackmore, Maureen (1993). THESEUS: a hypermedia browsing tool. British journal of educational technology : journal of the Council for Educational Technology. Volume 24, Number 3, 219-220, September.

Espinosa, R. & Baggett, P. (1994). A design for accessing multimedia information using cohesion. In J.D. Brouwer-Janse & T.L. Harrington (Eds.), Human-Machine Communication for Educational System Design, Eindhoven, The Netherlands: NATO Advanced Study Institute, Springer-Verlag: Series F: Computer and Systems Sciences, Vol. 129, 275-282.

Garzotto, F., Mainetti, L., & Paolini, P. (1996). Navigation patterns in hypermedia data bases. Journal of Organizational Computing and Electronic Commerce 6(3), 211-237.

Hirashima, T.; Hachiya, K.; Kashihara, A.; Toyoda, J. (1997). A browsing support facility in hypertext with user's browsing context. Jinko Chino Gakkaishi (Journal of Japanese Society for Artificial Intelligence). Volume 12, Number 5, 724.

Jungbauer, J., Baggett, P., & Ehrenfeucht, A. (1996). A browsing system based on multimedia cohesion. Paper presented at WebNet-96, World Conference of the Web Society, San Francisco, October 16-19, 1996. (A version of this paper was presented by Jungbauer at the ONR Workshop on Issues in Interactive Multimedia held in Las Cruces, Feb. 22-25, 1996.)

Jungbauer, J., Baggett, P., & Ehrenfeucht, A. (1996). A browsing system based on multimedia cohesion. WebNet 96 Proceedings, in both hard copy and CD-ROM formats.

Losee, R. M. (1997). Browsing document collections: Automatically organizing digital libraries and hypermedia using the Gray code. Information Processing & Management, Volume 33 (2), pp. 175.

McDonald, S. & Stevenson, R. J. (1998). Navigation in hyperspace: An evaluation of the effects of navigational tools and subject matter expertise on browsing and information retrieval in hypertext. Interacting with Computers, Volume 10, Number 2, 129.

Nielsen, J. (1990). The art of navigating through hypertext. Communications of the ACM 33(3), March, 296-310.

So, S.-K.; Ahmad, I.; Karlapalem, K. (1998). Allocating data objects to multiple sites for fast browsing of hypermedia documents. Proceedings, COMPSAC, the IEEE Computer Society's International Computer Software & Applications Conference, pp. 406.

Stotts, P. D. & Furuta, R. (1990). alpha Trellis: A system for writing and browsing Petri-net-based hypertext. Lecture Notes in Computer Science, volume 483, 471.

Tsirikos, D.; Markousis, T.; Mouroulis, Y.; Hatzopoulos, M. (1999). A client-server design for interactive multimedia documents based on Java. Lecture Notes in Computer Science, 1483, 248.

Wang, H. (1993). Partition of a bipartite graph into cycles. Discrete Mathematics. Volume 117, Number 1-3, 287.

4. Appendix: Questionnaire filled out by participants who used our two browsers.

Background Questionnaire

1. Age ________ Sex ___ Class Standing ________ Major/Dept. __________
   Native Language_____________ Second Language (if any)______________

2. Please indicate your previous experience with the following types of computer software. (1 = No experience 7 = Extremely experienced)
Operating Systems: Macintosh, Windows, UNIX,
Application Software: Word Processors (e.g., MS Word, WordPerfect)
Spreadsheets (e.g., Excel, Lotus)
Graphics Packages (e.g., Freehand, Photoshop)
Databases (e.g., MS Access, DBase)
Internet Applications: Telnet
File transfer programs (e.g., FTP, Fetch)
Web Browsers (e.g., Netscape, Internet Explorer, Mosaic)

3. Have you ever done any formal study of birds, academic or otherwise? If so, please elaborate.

4. Do you consider your knowledge of birds and their characteristics (e.g., migratory patterns, nesting habits, appearance) to be below, equal to, or above that of the average person?

5. Do you consider your interest in birds and their characteristics (e.g., migratory patterns, nesting habits, appearance) to be below, equal to, or above that of the average person?

Browser Tasks

Please use the provided browsing system to answer the following questions as best you can. Take as much time as you wish, and let the proctor know when you are finished. If you feel that you cannot answer a question with the available information, please indicate this in your answer. Answer all questions based on the information in the provided browsing system; assume that the birds in this system are the only birds with which we are concerned.

1. What color(s) is the female bobwhite?

2. Does the American bittern migrate? If so, briefly describe its migratory patterns.

3. Does the range of the kestrel include North America?

4. Which male bird leaves his mate to molt annually with other males?

5. Can you find a ring-necked pheasant in the United States?

6. Name a bird that breeds in Iceland.

7. How would you characterize the nesting habits of pigeons and doves?

8. Name some birds that make nests on the ground.

9. Name at least five birds whose range includes New Mexico.

10. Which bird has the scientific name Meleagris gallopavo?

11. Which birds have a range from Mexico to Ecuador?

12. What do birds in desert climates tend to eat?

13. See how closely related a pair of birds you can find. That is, find two (or more if you wish) birds that share the greatest number of common characteristics(e.g., similar diet, size, range, nesting habits, etc.). Describe how they are similar.

14. Are there certain regions of the world that seem to be inhabited by a great number of different birds? by very few birds? Give some examples of such regions and, where appropriate, the corresponding birds.

15. Find out as much as you can about a particular bird that interests you the most. Describe its characteristics (e.g., appearance, call, habitat, feeding habits, etc.).

Evaluation of the browsing system

Please answer the following questions regarding the browsing system you have just used.

1. Were you able to find the information that you needed to find?
(1 = I couldn't find anything   7 = I always found it easily)
If you had trouble finding things, what were they?

2. Did you get lost in the system? (1 = Always   7 = Never)
If and when you got lost, what did you do?

3. Did you have trouble figuring out how to use the interface?
(1 = All the time   7 = Never)
If you had trouble, what was difficult or confusing?

4. How did you find the number of options (choices of places to go) on each page? (circle one) too many   just right   too few

5. How did you find the organization of the material?
(1=Impossible to understand   7=No problem navigating and understanding)
If you had difficulty with the organization, explain why.

6. How did you find the quality of information available? (1 = Low   7 = High)
Specifically what did you find to be of low or high quality?

7. Describe those things that you liked about the interface, organization of material, and/or the rules of traversal (i.e., what you were allowed to do at each page).

8. Describe those things that you did not like about the interface, organization of material, and/or the rules of traversal.

9. Make some suggestions about how you would improve the interface, organization of material, and/or the rules of traversal.

10. Which properties of the birds did you find most interesting, worthwhile, and/or helpful? Least interesting, worthwhile, and/or helpful?

11. How did you find the amount of information on each screen? Too much, too little, just right?

12. How did you approach the task of answering questions? For example, did you browse around the system some before looking up specific information? Did you browse in order to find answers? Did you use a trial and error method? Were the names of the links helpful in determining where relevant information would be found?

13. How would you characterize the organization of the information in this system? Give your best description of the layout of the information; e.g., how the various types of pages are arranged. Feel free to use a drawing if it is helpful in conveying your perception of the layout.

14. If you could change where the buttons for traversal are placed, or your entry point to a given bird, how would you do it?

15. Did you notice that when you selected a (new) subway line, you didn't immediately go to the first stop on that line, but you then had to select 'next' to get to the first stop? Did you like this feature, or did you find that is slowed you down?

16. What did you think of the buttons labeled 'next', 'previous', 'back', and 'forward'? Did you understand their meaning? Did you use them?

17. Did you notice that when you were at a subway stop, you were not told how many stops there were on your line, or which stop your current one was?
Would you have preferred to be told at each stop, for example, "You are on stop 3 of 5 of the xxxx line"?