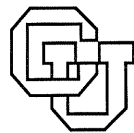


**A Browsing System based on Multimedia Cohesion**

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## I. Introduction

What is a browser?

We talk about browsing when the user can recognize valuable or relevant information but is unable or unwilling to ask for it. Cohesion (or coherence) is a term that originated in psycholinguistics. Cohesive elements of a text are key ideas that are repeated in the text over and over again, and which together form a main topic of discourse. High cohesion distinguishes a meaningful text from a random collection of sentences. In general, a common feature of a group of items may be called a cohesive element for the group.

Examples of browsing in everyday life

1. An old book collector's dream is to find a valuable book that is not listed in any catalog, but which is virtually unknown. Of course one cannot ask for such a book, but one may find it by browsing in an antique store between cookbooks and old photos, on a shelf labeled miscellaneous.
2. Keys to flowers and trees are not generally organized according to scientific classifications. The structure of a flower, which is the basis for scientific classification, requires expert knowledge, and it is often hard to observe. On the other hand, an experienced amateur can recognize that a specific picture and description of a species match a given specimen. A typical flower guide groups flowers by colors. A color, such as lavender, is a cohesive element for each group. Within each group, the flowers are arranged by placing the most similar ones next to each other. The user may choose the color on the basis of the specimen at hand, and browse through the list until he or she finds the right match. There are other possibilities for organizing a key. Cohesive elements may be geographic regions, type of habitat, season of flowering, and so on.
3. Very few supermarket shoppers have a shopping list that specifies each item completely. Most shoppers go to the proper aisle, e.g., dairy products, canned vegetables, toiletries, and browse to get the best bargain. (Stores encourage browsing because browsers buy more.) Here, the cohesive elements for each aisle are usually clearly marked and displayed, such as bakery goods, Mexican foods, and so on.

The common theme among the above examples is that items are grouped by cohesive elements, and users browse by scanning the items within one group. Users do not choose the cohesive elements; instead, the elements are selected by store owners, supermarket managers, or authors of flower keys. For example, in a supermarket one can put together canned goods, mixing meat products with vegetables, or one can put together vegetables, mixing together fresh and canned produce.

Learning by browsing along a cohesion path

There are some central ideas which form a cohesion path that crosses different disciplines. Preservation of energy is a central idea of physics, chemistry, cosmology, and many other domains. Organizing learning along such ideas counters fragmentation and over specialization, which are characteristic of modern scientific development.

Besides classifying information by content, we can classify it by media: English text, Spanish text, audio, movie, graphic, video, interactive video, and their combination. Media may also act as cohesive elements which correspond to grouping information by

form of presentation. Different media are often difficult to combine. In a book about birds, we have text and pictures, but we cannot include chirping or acrobatic flying, which can be heard and seen in a movie.

In all sequential media, e.g., written or spoken text, movie or video, each item can lie on only one cohesive path available to a browser. If flowers of one color are put together, then flowers from the same region must be scattered throughout the book, and vice versa. Using hypermedia to construct a browsing system is a very attractive solution to this dilemma. Then the user of a system may choose the browsing path, following color (blue), or blooming season (April), or habitat (desert), getting the advantage of all cohesive elements within one tool. Also existing hypermedia techniques can overcome the boundaries among media, allowing their simultaneous combination.

The goal of this project is to apply the concept of cohesion to a multimedia browsing system. The system we are developing is described in detail in III. below.

## **II. Previous research**

### **A. Psychological studies**

As mentioned above, the concepts of text coherence and cohesion have been used by many authors in the psycholinguistics literature (Halliday, 1985; Halliday & Hasan, 1976; Grimes, 1975; Harris, 1952; Kintsch, 1974; Kintsch & vanDijk, 1978). Two items in a text are said to be cohesive if they refer to the same concept. In the schema of Halliday & Hasan (1976), examples of cohesion include repeated words, a noun and its pronoun referent, and the use of synonyms. These authors claim that cohesion provides semantic continuity and improves a text's intelligibility. An extended treatment of text coherence can be found in Kintsch (1974).

The notion of text cohesion was extended to visual, and to visual and verbal cohesion by Baggett & Ehrenfeucht (1982). In their schema, two items from different media (textual and visual) were termed cohesive if they referred to the same concept (e.g., the word 'husband' and a picture of a 'husband'.) They described a cohesion graph for frames from a movie; with it, a measure of the closeness of cohesive elements in a sequence of frames could be determined. In one experiment, participants were asked to put still frames from a movie that they had not seen into a sequence so that they "make a good story". Participants grouped together cohesive elements significantly more closely than they actually occurred in the movie. The authors interpreted this result to mean that people are aware of cohesive elements and use them in grouping material.

### **B. Some earlier implementations**

Here we briefly describe some of our previous implementations of browsing systems based on multimedia cohesion. (Discussions of other approaches to multimedia browsing can be found in Allen, 1995; Cruz & Hill, 1994; Stotts & Furuta, 1989; Zellweger, 1989.)

(1) Baggett, Ehrenfeucht, & Guzdial (1989) implemented a graphics-based instructional system for assembly and repair of a toy "string crawler", a battery-powered vehicle which traveled along a string when it was turned on. Access was via graphical and textual cohesive elements. Users could follow any of 21 different concepts (e.g., switch box, wire, motor) through the 41-frame presentation.

(2) In "Where in History is Mathematics?", a project in two graduate software design classes, users could investigate the six different civilizations which, according to current knowledge, developed mathematics at least in part independently: Africa, Sumer-Babylon, India, China, Maya, and Inca. Cohesive elements included zero, counting schemes, famous individuals, games, and tools.

(3) "Footloose in Washtenaw County, Michigan", another project in a software design class, was a multimedia (videodisc-based) implementation of sites one could visit. Cohesive elements included cross-country ski areas, bird-watching locations, and old churches.

(4) In an implementation of 183 Emily Dickinson poems and critiques of them offered by four authors (Espinosa & Baggett, 1994), cohesive elements were 16 abstract themes (e.g., love imagery) together with the poems themselves. The material in this system was text only.

It should be noted that none of the above implementations was a complete browsing system. They did not provide an authoring tool, so each one was restricted to being used as a browser of a specific presentation. The current system being developed is much more general, as described below.

### **III. Current design and implementation**

#### **A. Users of the system**

In all browsing schemas we have two participants: an author, an expert who arranges the material and identifies or creates cohesive paths, and a learner who chooses and follows a path in search of information. In an experimental setting, there is a third participant, a researcher, who can observe the learner (or the author), analyze their behavior and the workings of the system, and plan experiments.

#### **B. Data structure**

The material to be browsed will be organized into a data structure that groups cohesive materials together. This data structure is essentially a graph. Each multimedia document is assigned to a node in the graph (possibly more than one document per node), and nodes that share a cohesive element are linked together into a cohesive path. Nodes may belong to more than one cohesive path, and one special node, the home node, belongs to every cohesive path. Each path is circular and has a default order on its nodes so that the home node is both the first and last node in every cohesive path. Since nodes may belong to more than one cohesive path, these paths may intersect. The default ordering of nodes within a cohesive path will determine the order of forward traversal when the graph is used to browse the material, and the intersection points (nodes) are where travel along one path may yield to travel along a different path.

#### **C. System components**

This section describes the current implementation of our browsing system. Three components have actually been designed, each of which corresponds to one of the three types of users described earlier. The first to be implemented is the authoring tool, which

is used by the author to create the presentation to be browsed. The second piece being developed is the browser, with which the learner will browse the presentation. The final component consists of facilities for the researcher to analyze the learner's session in the browser. At the present time, only the authoring tool has been partially implemented.

## 1. Authoring tool

The authoring tool provides the functionality needed for the author to create a multimedia presentation. The underlying data structure for a presentation is the cohesion-based graph discussed previously. Because of this, the terms "graph" and "presentation" will often be used interchangeably in this discussion.

To facilitate the author's creation of a good presentation, the authoring tool provides the author with services for both constructing the underlying graph and analyzing the graph that has been built so far. With respect to graph construction, the author has three primary tasks:

- \* assign the materials to be browsed to individual nodes
- \* decide on cohesive elements among the nodes
- \* establish the order of nodes within each cohesive path

The authoring tool accommodates the author by providing this functionality. In order to assign the material to nodes, several node-level operations are available. The author may create new (initially empty) nodes and delete existing nodes. The author may also edit an existing node by editing its default text or its document references, which point to any multimedia documents associated with the node. To establish cohesive relationships, the author may add and remove nodes to and from cohesive paths corresponding to specific topics. (Because cohesive paths correspond to lists of nodes sharing a common topic in the presentation, they will often be referred to by other interchangeable names, such as "cohesive topic lists" or "topic lists." Similarly, we use the terms "topic" and "cohesive element" interchangeably.) The author may determine the order of nodes within cohesive paths by viewing the topic lists and rearranging the nodes in these lists. The author may also manipulate the graph at the topic level. The author may create and delete topics, as well as add and remove entire topic paths to and from the home node of the graph. This effectively allows the author to include or exclude entire cohesive element paths. In this way, the author may experiment with changing the presentation at the path level while still keeping unused paths around to be "attached" when needed.

As for analyzing the current graph, the author may perform several operations on the graph to determine some of its properties, such as the longest cohesive path, the largest number of links to any node, or the longest or shortest path between two nodes. Some automatic checking of the current graph will also be done by the authoring tool. While constructing the presentation, all operations (e.g., adding and removing nodes and topics) will be checked by the system to ensure that the author may not manipulate the graph in such a way as to make it inconsistent with our model of a legal cohesion-based graph.

## 2. Browser

The product of the authoring process is a completed presentation. This presentation is input to the browser, which allows the learner to traverse the graph and browse the materials it contains.



## Traversal

The browser allows the learner to traverse the graph in a rather restricted way. The basic rules of traversal are as follows. A learner may:

- \* move to the next node within the current active path
- \* move to the previous node within the current active path
- \* move to the next node in an intersecting path (when currently at a node belonging to multiple cohesive paths)
- \* move immediately to the home node
- \* backtrack through the most recently visited nodes

The notion of the "active path" refers to the path corresponding to the most recently selected cohesive element. When moving to the "next" or "previous" node from a node belonging to more than one path, the learner will move to the node belonging to the same topic that had been followed up to that point. Aside from jumps to home and backtracking, the learner's traversal may be summarized as follows: a learner must move one node at a time and must remain on the same cohesive path, except when at a path intersection; at an intersection, a move to the next node on any intersecting path is allowed. Note that the learner has the choice of any topic path in the presentation when at the home node. A good analogy for this type of traversal is travel along a bus route. A rider may continue on a given bus line or may transfer to another route at any stop where routes intersect. A possible advantage to this method of traversal is that the learner is not forced to make decisions about what topic to select next (except when starting at the home node). He or she may simply follow the default ("next") links through a cohesive path, although the option of leaving the path is available at intersection points. This reduction in decision making may allow for more focus on the material rather than on the traversal.

## Node display

In addition to enforcing the rules of traversal, the browser is of course responsible for displaying the documents associated with each node. It is left to the author to determine what materials are included with each node, but in any node it is possible to have default text that is automatically displayed when the node is visited, as well as supplemental links to documents of many other media. These are referred to as supplemental links to distinguish them from traversal links that connect nodes. Supplemental links may be used only to access multimedia documents (e.g., play a sound file or a video clip) associated with a given node, and not to move from that node to another part of the graph. They can be thought of as extending the node. Each node will generally correspond to a one page on-screen display. Upon arriving at a node, the learner will typically see the default text for the node, the mandatory traversal buttons (Next, Previous, Home, and Back), any intersecting path transfer links (if at a node belonging to multiple cohesive paths), and any supplemental document links. Each supplemental document may have its own display page as well, which will of course provide a mechanism for returning to the default page for the node.

## 3. Research Facilities

The primary mechanism available for examining a learner's use of the browser during a session will be a log file in which all learner actions will be logged and time stamped. This record will allow analysis of a learner's behavior, such as the amount of time spent

on certain parts of the graph and which nodes were accessed most frequently and in what order. In addition to the log file, it is possible that direct observation of browsing sessions will be used in the analysis, as well as post-session interviews with the learner.

#### **IV. Experimental parameters**

Some of the characteristics of the system we are developing cannot be determined without first using the system in an experimental fashion to help determine some parameters. This is particularly true of the browser, whose features and layout may significantly affect the behavior of the learner. There are also parameters associated with the actual presentations being designed that will have to be varied in order to determine what is reasonable and usable for the learner. Some examples of such parameters to be determined experimentally are:

- \* The number of cohesive elements per node
- \* The distribution of cohesive elements over nodes:  
Should some nodes act as hubs belonging to many cohesive paths?  
Or should there be an even distribution of topics per node?
- \* The distribution of supplemental documents over nodes:  
Should many supplemental multimedia documents be linked to one node?  
Or should each multimedia document be on its own node?

#### **V. Research questions**

We are also interested in broader questions about the value of a browsing system based on cohesion for both learners and authors. For example,

What are the benefits of this kind of active exploration for the learner?

Will some cohesive paths be followed more frequently than others?

Will the learner get lost?

Will the learner find what he or she is seeking quickly and efficiently?

Will the author be able to influence the user's learning by the manner in which the cohesive elements are selected and linked?

#### **VI. Acknowledgments**

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