The Sentient Map as a New Paradigm for Human-Computer Interface

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Abstract

The *sentient map* is a map that can increase the user's awareness by sensing the user's input and generating the appropriate reactions such as retrieving and presenting the relevant information to the user. We describe the sentient map in an application as the user interface for the Growing Book that is a constantly expanding electronic book for e-learning, and then discuss the design of the experimental sentient map system.

1. The Sentient Map

The *sentient map* is a map that can increase the user's awareness by sensing the user's input and generating the appropriate reactions such as retrieving and presenting the relevant information to the user. Sentient maps can serve as indexes and lead the user to more information. In practice a sentient map is a gesture-enhanced interface for an information system. A companion paper [Chang01] describes the motivations for the sentient map paradigm and the gesture query language in greater detail. Therefore in the present paper we will concentrate on illustrating the use of the sentient map in one important application area, i.e., e-learning.

First, we repeat here the formal definition of the sentient map [Chang01].

A sentient map *m*=(*type*, *profile*, *v*, *IC*) has a *type*, a *profile*, a *visual appearance*, and a set of *teleactivities*.

A sentient map's *type* can be geographical map, directory page, web page, document and so on.

A sentient map's *profile* consists of attributes specified by its creator for this map type.

A sentient map's *visual appearance* is defined by a visual sentence *v*, which is created according to a visual grammar or a multidimensional grammar.

The *teleactivities* of a sentient map is defined by a collection of *index cells IC* [Chang95]. Each index cell *ic* may have a visual appearance, forming a *teleaction object*. These teleaction objects are usually overlaid on some background.

Ignoring the type and profile, a sentient map is basically a collection of teleaction objects including a background object.

A *composite sentient map* is defined recursively as a composition of several sentient maps.

Maps are widely used to present spatial/temporal information to serve as a guide, or an index, so that the viewer of the map can obtain certain desired information. Often a map has embedded in it the creator's intended viewpoints and/or purposes. A web page can also be regarded as a map, with the URLs as indexes to other web pages. In fact, any document can be regarded as a map in a multi-dimensional space. Moreover, with associated scripts, the maps can also be made active [Chang95]. These two notions, that data can be viewed as maps and that maps can be made active, led us to propose a new paradigm for visual information retrieval - the sentient map. The natural way to interact with a sentient map is by means of gestures. In the companion paper [Chang01] we describe how simple gestures called *c-gestures* consisting of mouse clicks and keyboard strokes are used to interact with a sentient map.

This paper is organized as follows. For empirical study, Section 2 describes an e-learning environment called the Growing Book that serves as a test bed. In Section 3, we discuss the design of the sentient map system.

2. The Sentient Map Interface for the Growing Book

A *Growing Book* is an electronic book co-developed by a group of teachers who are geographically dispersed throughout the world and collaborate in teaching and research [Chang00]. Since the course materials are constantly

evolving, the Growing Book must be constantly updated and expanded. The Growing Book is used by each teacher both in the local classroom as well as in the distance learning environment. Therefore the Growing Book must be accessible by multilingual students. The chapters of he Growing Book are owned by different instructors who may utilize and/or provide different tools for distance learning, self learning and assessment. In what follows, we describe a prototype [GB01] and its sentient map interface, to serve as a test bed to investigate how to design and manage the Growing Book so that it can be accessed universally by people with different linguistic skills and cultural background for effective teaching and research.

A sentient map *m* for the Growing Book typically has the type "chapter". Its *profile* has the following attributes: **Chapter_No:** the numerical id of the chapter, **Chapter_Title:** the title of the chapter, **Chapter_Password:** the password in order to update the profile or perform privileged operations, **Chapter_URL:** the URL of this chapter, **Author:** the author, or authors, of this chapter, **Teacher:** the teacher, or teachers, of this chapter, **Student:** the student, or students, of this chapter, **Who_is_Who:** the known authorities on the subject matter of this chapter, **Center_of_Excellence:** the known centers of excellence on research related to this chapter, **Reference:** the references for this chapter, **Tool:** the software tools useful for this chapter, **Privacy:** a list of user names who want to keep their personal information off the awareness list, and **Awareness:** the awareness list specifies what the user want to be informed of.

This profile is used to increase the awareness of the user. The commands supported by the Growing Book include the following: ABSTRACT: Create an abstraction of a chapter at a certain level. SEND_AUTHOR: Send a message to the author(s) of a chapter. SEND_TEACHER: Send a message to the teacher(s) of a chapter. SEND_STUDENT: Send a message to the student(s) of a chapter. ADD_AUTHOR: Add to the author(s) of a chapter. ADD_TEACHER: Add to the teacher(s) of a chapter. ADD_STUDENT: Add to the student(s) of a chapter. DROP_AUTHOR: Drop from the author(s) of a chapter. DROP_TEACHER: Drop from the teacher(s) of a chapter. DROP_STUDENT: Drop from the student(s) of a chapter. SET_AWARENESS: Set the awareness profile. SET_PRIVACY: Add someone to the privacy list. CHECK_AWARENESS: Check the awareness profile. AWARE: Display info one should be aware of. ADD_WHO-IS-WHO: Add to who-is-who. ADD_CENTER: Add to centers of excellence. ADD_REFERENCE: Add to reference(s). ADD_TOOL: Add to tool(s). ADD_WATERMARK: Add watermarks to the html files of a chapter. DISPLAY_WATERMARK: Display watermarks of the html files of a chapter. WEAVE: Weave pieces of the same type, such as sound bytes, into a presentation. MATCHPAR: Define Growing Book working directory and matching parameters.

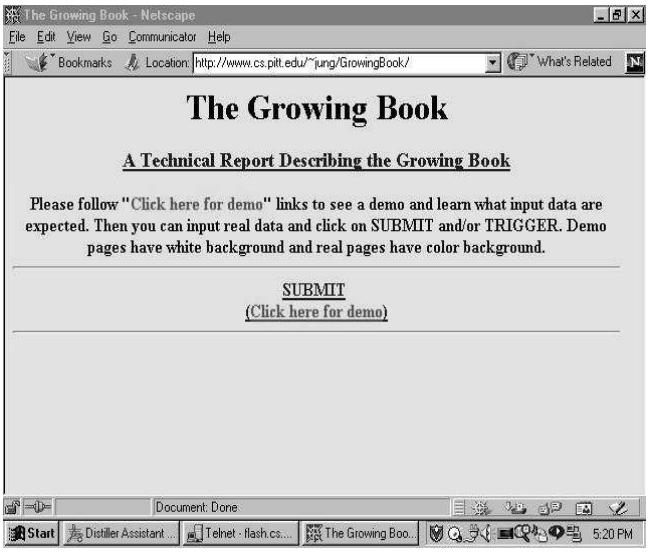

Figure 1. Top page of the Growing Book.

The Growing Book is designed using the Active Index System as the underlying coordination and control system. The commands described above are message types for the Active Index System. In Figure 1, the top page of the Growing Book is illustrated. The user can click on the red DEMO link to first see a demo and learn what input data are expected. Then the user can input data and click on the SUBMIT link.

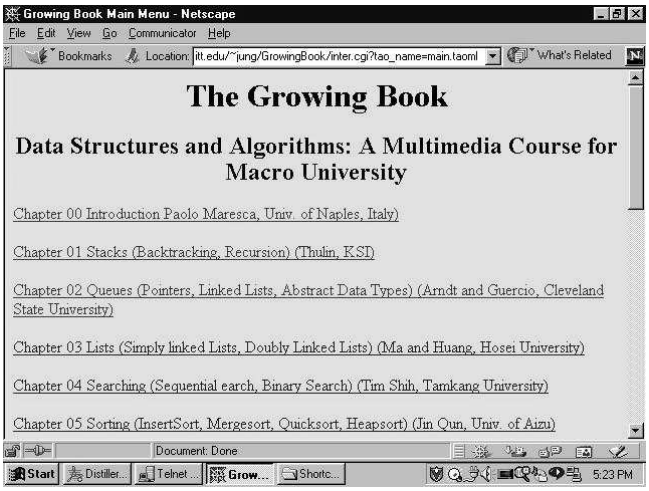

Figure 2. The contents of the Growing Book.

The contents of the Growing Book are illustrated in Figure 2. The user can enter a number of commands to manipulate the Growing Book. For example, the *weave* command weaves the media objects of a certain type together to give a streamed presentation. The *matchpar* command enables the user to set the parameters to search the Growing Book. Once the parameters are set, the user can search for documents similar to a document.

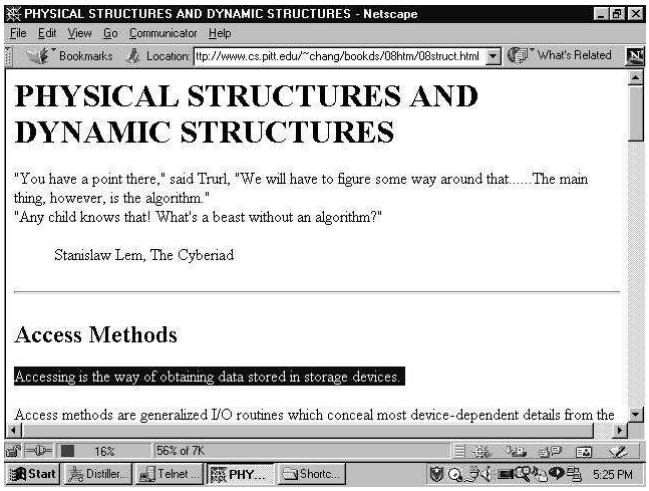

Figure 3. Finding similar documents by highlighting a paragraph in a document.

The words in the paragraph highlighted in Figure 3 are matched against the words of the documents in the Growing Book at different levels of abstraction, so that the matched documents can be identified. The Sentient Map can then be used to visualize and retrieve the documents. Since more details can be found in the companion paper [Chang01], only a brief discussion is given here. The Sentient Map can be integrated with the NetICE environment for virtual teleconferencing developed by Dr. T. Chen at Carnegie Mellon University [NetICE99]. Students and instructors can use this environment as a virtual classroom. Several users represented by their *avatars* are engaged in a discussion, as shown in Figure 4.

Figure 4. A NetICE conference room. Figure 5. A Sentient Map. Figure 6. Sentient Map after point gesture.

When they need information they may turn their attention to the sentient map (in bitmap-formatted mode) displayed on the wall, and more information becomes available and is also visible to all the participants of the virtual teleconference. In the current prototype system, three maps represent three point query types -- instructor, subject and title, as illustrated by Figure 5. The user can then use the point c-gesture (a double click) to query on the map. For example, if the user clicks on the subject map, an input window will pop up to let him/her input what subject he is interested in, such as "software engineering" or "data structure". At the same time, a world map will be displayed to let user go on with his/her gesture, as illustrated by Figure 6.

3. The Design of the Sentient Map System

The system architecture of the sentient map system is illustrated in Figure 7. The sentient map system, whether in bitmap-formatted mode or html-formatted mode, accepts the user's gestures, pre-processes them, and sends messages to the Gesture Analyzer. The Gesture Analyzer is an IC-based analyzer [Chang95]. The different messages drive the ICs to change from one state to another and perform pre-defined actions. For example, commands for the Growing Book are the currently supported message types. The Gesture Analyzer produces SQL query for the database. After the result is retrieved from the database, it is visualized and the user can see the well-formatted results for the input gesture query.

The **Sentient Map Interface** in html-formatted mode will be explained here. It deals with web pages in html format and has three components. In the first component, a function **getString** is written in JavaScript and embedded in html files. It will get the highlighted text in a web page and change it to the format that can be used as a parameter in a "POST" message, for example, by changing "space" to "underscore". In the second component, a CGI function **timeline.cgi** will accept that modified parameter, extract it to its original format by calling **getcgivars()** (i.e. changing "underscore" back to "space"). Then this parameter will be analyzed by several methods, and the database most relevant to it is selected by a majority vote of the results, and the results are visualized. In the third component, an applet called **MyTQuery** is activated. The functionality of this applet is to present the interface of the query input, perform that query on the related database and show the final result. In this applet, we defined several functions, such as function **getQuery()** that will write a query by using SQL (Structured Query Language), **getTable()** that will connect to the related database by using JDBC (Java Database Connectivity), and **displayResult()** that will show the final query results by popping up a small window.

The **IC-based Gesture Analyzer** of the sentient map interface sends user's input to the IC-based Gesture Analyzer. An index cell (IC) is an active object with states, transitions and actions. The IC development tools include the IC_builder, the IC_compiler and the IC_manager. The designer uses the IC_builder to design the ICs' states and actions, and then uses the IC_compiler to compile them. The IC_manager manages the ICs. The IC for the Gesture Analyzer is illustrated in Figure 8.

The **Similarity Matcher** performs matching of sentient maps. Currently it is based upon keyword matching, and a new version will support matching of images and videos. Finally, the **Result Visualizer** supports the visualization of retrieved results.

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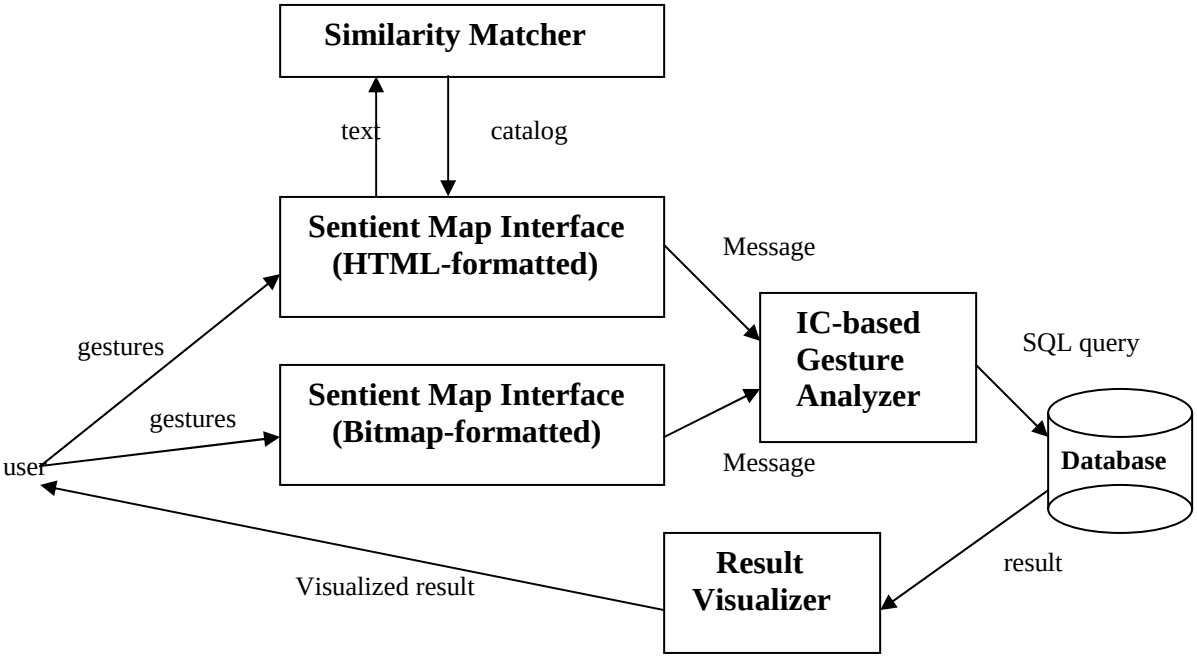

Figure 7. Sentient Map System Architecture.

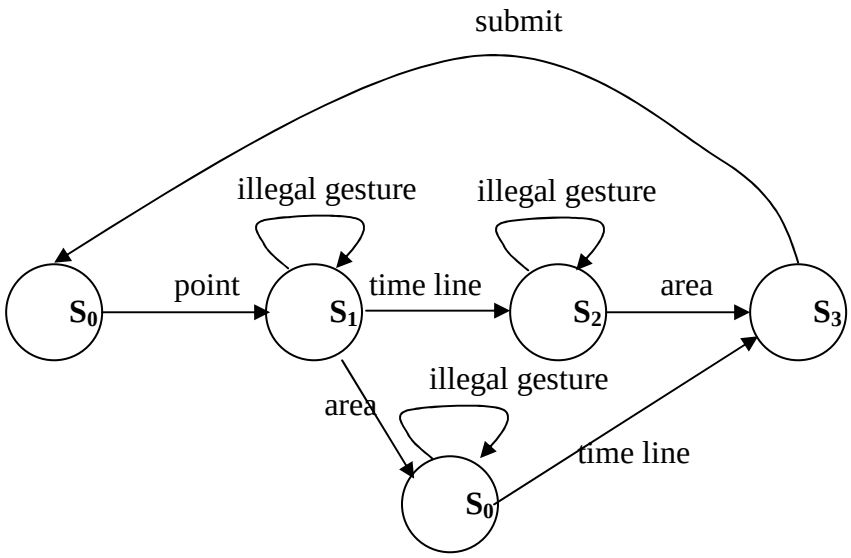

Figure 8. IC state transition graph for the Gesture Analyzer.