Implementing the Cognitive Layer of a Hypermedia

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Abstract

The most significant advantage offered by hypermedia is the possibility of implementing a large variety of cognitive paths, using links to represent both extensional and intensional associative aspects. Authority files and thesauri can act as the most appropriate tools to build the cognitive layer of hypermedia, playing a twofold role: to formulate the query using a normalised language and to exploit the power of the cognitive layer as a large set of semantically rich links the user will activate according to his/her specific interests. In this paper, we present the use of an authority file on authors and the ICONCLASS classification system to implement the cognitive layer of hypermedia and enhance user's search and navigation capabilities.

Keywords

Hypertext, Hypermedia, Design, User interface; Access

1. Introduction

The richness of relationships among information items and the variety of scientific and cultural interests that characterise the potential users of applications concerning the cultural heritage makes it one of the most suitable and challenging areas for the implementation of hypermedia applications.

"Information highways" which make available all the information the scholar needs, and provide access to the right information , strongly augment enthusiasm in the field and the scholars' expectations. However, the enthusiasm for this very powerful technology tends to diminish the importance given to some more "traditional" approaches. As a consequence, some projects, in spite of the presence of many technical gadgets, end in disappointing results and a waste of resources.

In this paper we describe how we used some "old-fashioned" tools, like cataloguing cards, authority files and thesauri to implement the cognitive layer of the hypermedia, in a project whose aim is to develop a uniform interface for databases of Italian cultural heritage.

2. Some Reflections on Hypermedia Design

We must remember that the most significant advantage offered by the hypermedia is the possibility of using "links" to implement a large variety of cognitive paths, each one tailored to the specific interests of the user, between information nodes that constitute the "*data space*". Therefore links constitute probably the most relevant component of hypermedia, as they represent the associative aspect, and are extensional as well intentional.

As pointed out elsewhere, the extensional links are essentially structural links, that come from the intrinsic connection between two nodes, as it may happen for two components of a work of art. However, the intensional links constitute a very different case, as they would model the associative process typical of the human mind. We can attempt to emulate this process implementing a "*concept space*", that makes explicit the relationships existing among the concepts that can be attached to the single information node. By this approach, we can represent the knowledge on the specific semantic domain, and therefore we are no longer forced to make explicit all the possible links existing among the various nodes.

Navigation through the concept space enables the user to operate an abstraction process, then follow the associations among the concepts, and finally descend into the *data space*, creating his/her own personalised cognitive path. This process appears much more similar to the natural process of the human mind, as results in supporting a large number of potential links among the nodes, but avoiding their proliferation overloading the node or disturbing the user.

The first step in hypermedia navigation is often the selection of a node. Subsequently, the user will fol-

low the explicit links connecting the current node with others containing somehow related information. It appears that we are faced with two kinds of problems.

Firstly, if the user cannot suitably express what he/she is looking for, the system cannot give adequate results.

Secondly, the requirement for an explicit representation of links with other nodes reduces the actual number of potential paths to follow, basically because:

- every link points to a single target element (node or component of a node);
- too many links on a single node constitute bad design practice, either because the node itself will become less "readable and appealing", or because the cognitive overhead would certainly disturb the user.

These two kinds of problems have solutions.

Finding a satisfying access node, we meet all the well known and widely discussed problems in Information Retrieval Systems, as the user must identify the contents of what he/she is looking for, formulate the query and begin a research for a particular subject. The precise identification of search terms and document semantics strongly enhances precision and recall. To this end, great support comes from *language normalization* and *data structuring*.

The second type of problems is more closely related to the design of hypermedia, intended as the integrating tool for querying, accessing and navigating on heterogeneous information (texts, images, maps, etc.). As discussed in several other papers ([CACM9508], [Signore95c], [Signore95d], [Signore96]), the designer can get much help from adopting a coherent design methodology, that permits the identification of the various interaction metaphors and implements hypermedia's conceptual level. The user should be able to navigate in this space, to find the relevant concepts attached to the information nodes belonging to the data space. This conceptual model permits the identification of many, and sometimes unexpected associations between information nodes. We can call it the cognitive layer of the hypermedia, or the layer where the user will really experience the "freedom to associate".

As a logical consequence of previous considerations, it is important that an effective hypermedia has an interface to access authority files and navigate concepts. Therefore it is necessary to represent the semantic knowledge of the specific domain. From the experience developed in the context of Information Retrieval Systems, we can probably argue that the most common way to do this is to use a thesaurus, thereby modelling equivalence, preference and hierarchical relationships between concepts.

3. The Project

The main objective of the project was to build a uniform, user friendly and effective interface to ICCD databases. In the following section, we will describe the basic components of this system: data, authority file on artists, and an iconographic thesaurus.

3.1 The Data Space

Data describing works of art are stored as catalogue cards. Some of the features of this approach have been described previously[Signore91].

The definition of the data structure is based upon the identification of the central role played by the object. It was agreed to define a classification schema based on three different kinds of objects: simple objects, complex objects, aggregations of objects.

A *simple object* is an object such that all his attributes are pertinent to the whole object, and no components which may themselves be considered cataloguing objects may be identified.

A *complex object* may be or a simple object whose parts, physically or conceptually separable, exhibit some interesting peculiarities as cataloguing objects, either a set of objects which may be referred by a specific name.

The *aggregation of objects* arises when several objects are correlated on the basis of some conceptual criterion, but no name exists which identifies the aggregate.

It is obvious that the components of a complex object may be either simple or complex objects, as is also the case where aggregate objects are concerned.

It is worthwhile to note that a specific object belongs to the different categories only on the basis of the quantity and the type of information: no list exists that specifies that a particular kind of object must be considered simple, complex or aggregate. The proposed model only establishes a classification model, that is, the type of relationships that must be specified between the objects (e.g. a component of a complex object is an object itself), and the criteria of inheritance of these properties.

Even if the adopted approach was essentially based on the standard methodologies currently used in conceptual database design, it is more productive to use the conventional "cataloguing card" format as an alternative way of representing information.

From this point of view, the following choices were made:

- the information was divided into small, semantically well defined, chunks;
- these chunks may be either a field, either a subfield of a structured field;
- each field may be defined as simple or structured;
- each field may be defined as repeating or non-repeating;
- each subfield may be a repeating or non repeating subfield;
- fields, either structured or unstructured, may be grouped into "paragraphs" in order to allow multiple occurrences of a set of fields.

At first glance, the proposed model may appear just another "flat file" schema, with a large number of fields, but anyone familiar with the database design methodologies will easily recognise that, generally speaking, entities have been mapped onto paragraphs, (multivalued) attributes onto (repeating) fields, aggregate attributes onto structured fields.

It is also evident that the identification of a sequence of fields, with the characteristics of being repeatable and/or groupable, and references to "authority files", may be seen as the "linearization" of a non-linear text.

The interested reader can find guidelines followed in the definition of the standards and their complete definition in [D'Amadio89], [Massari88], [Montevecchi89], [Papaldo86], [Papaldo88], [Parise88].

3.2 The Artist Authority List

This authority file (about ten thousand entries) contains descriptive data about all Italian artists, organised according to the schema defined by the ICCD. All the information is subdivided in several fields, namely:

- preferred name (the name used in the cataloguing cards);
- other names;
- place of birth;
- date of birth;
- date of death;
- place of death
- period of activity;
- school;
- role (painter, sculptor, etc.)

and so on. It is easily seen that these data can be used not only to select the right name to use in searching, but also to establish relationships among artists based on several characteristics, like school, period of activity, places.

3.3 The ICONCLASS Classification System

In art history applications iconographic classification plays an essential role, both as key to access the right information, and as a support to identify possible associations among different works of art or put them in the appropriate conceptual context.

ICONCLASS (Iconographic Classification System) is an iconographic classification system built on hi-

erarchical principles, originally devised by the late Henri van de Waal, professor of Art History at the University of Leiden. The printed version of ICONCLASS ([ICONCLASS]) is the result of forty years of iconographic research by a team of scholars. In recent years ICONCLASS became the most widely accepted classification system for visual documents, in use by individual iconographers and public institutions. ICCD adopted it as the national standard, and recently completed its translation into Italian.

An ICONCLASS browser, implemented by the ICONCLASS Research & Development Group is available on the market ([IRDG92]).

Figure 1 shows a small subset of an ICONCLASS hierarchy. For the moment, it is important to remember that every notation identifies a unique subject, and that every subject has a set of associated keywords that can refer top other subjects, too. Finally, we must stress that the usage of an alphanumeric notation assures a good linguistic independence.

Notation	Subject
1	Religion and magic
10	(Symbolic) representations in relation to creation, cosmos, cosmogony, universe, and life (in the broadest sense)
11	Christian religion
11 A	Deity, God (in general) in relation to Christian religion
11 A 1	God the creator
11 A 11	God measuring the Universe (with compasses)
11 A 2	Divine Nature
11 A 21	Divinity
11 A 22	Symbols in relation to Divine Nature
11 A 22 1	Circle symbolizing God's perfectness
11 A 23	God's perfections
11 A 3	God's wrath
11 A 31	'Flagello di Dio'
11 B	Father, Son and Holy Gost in relation to Trinity
...	...
11 C	God the Father
..	...
11 D	Christ
...	...
11 E	The Holy Gost
...	...
11 F	The Virgin Mary
...	...
11 G	The Angels
...	...

Figure 1 - A Sample ICONCLASS Hierarchy

4. The User Interface

As pointed out before, the main objective of the project was to build a uniform, user friendly and effective interface to ICCD databases. Quite naturally, the design has been centred on user needs. We hypothesised that the typical process would be:

- access an information node,
- choose an association mechanism,
- use the corresponding metaphor,
- access one or more information nodes,
- repeat the process.

Among the particularly relevant principles are data structure, and normalization of language, based on extensive usage of thesauri and authority files. Keeping in mind that authority files are not simply a list of terms, as every entry contains additional information, the user interface has been designed to allow concept browsing, with the ability of storing retrieved items as search terms in formulating the query.

Therefore, authority files and thesauri can act as the most appropriate tools to build the cognitive layer of the hypermedia. More precisely, they play a two-fold role:

- browsing them, the user can find or refine the concept and the words to use for selecting the relevant node, so acting as a tool to formulate the query using a normalised language, avoiding false hits and missing retrievals;
- once the user is located on an information node, any term based on authority file or thesaurus can activate a navigation in the conceptual space, so exploiting the power of the cognitive layer as a large set of semantically rich links, that the user will activate according his/her specific interests.

Currently, we have implemented a user interface that makes use of an authority file for authors and of the ICONCLASS classification system to implement cognitive layer and enhance navigation capabilities. When navigating on both the authority file and ICONCLASS, the user can select terms to be used in a subsequent query. Conversely, the card describing the object shows terms controlled by the authority file and by ICONCLASS as links for further navigation and query.

4.1 The Search Page

The main interaction of the user with the database occurs by way of a search and display page, where the user can specify values for the supported access points to the database. At present, author and iconography are the only supported access points. As in almost all user interfaces, the user can specify a desired value, and the system will implicitly assume a Boolean OR between values entered for the same field, and a Boolean AND for the values specified for different fields. So that the user can be sure to specify the correct indexing values for the access points, he/she can ask for help, invoking the implemented browsers.

As we will discuss afterwards, the search page will also be used as card display page.

4.2 The Artist Authority List Browser

Navigation on this file allows the selection of the name used to index works of art, or browsing through schools and finding artists of interest, or related together. When using this browser, the user can interrogate the database entering desired values for name, school, role. The system will return a list of artists (in "brief" format) that the user can browse, asking for more details, selecting the relevant values for the subsequent query. Therefore, this browser can help in refining the selection terms, assuring that the specified values are exactly those used in indexing the cataloguing cards.

4.3 The ICONCLASS Graphical Browser

The ICONCLASS browser is even more sophisticated and powerful. This is essentially due to the intrinsic richness of the ICONCLASS system itself, where iconographic subjects are not only arranged in hierarchical order, as an ordinary thesaurus, but also connected by keywords, that allow the implementation of an extremely rich set of connections. The relevant features of the implemented browser are the graphical representation of the hierarchy, the possibility of retrieving codes and subjects both in English and Italian, the link from subjects to sample images, that help to find typical representation of subjects.

The navigation interface is made up of four distinct areas (Figure 2), which interact in a well defined fashion. In more detail, we have the following areas.

- *Structure*: shows the subject hierarchy as a tree.
- *Code:* contains the ICONCLASS notation (code) and the subject. A small icon can be present, indicating that a "typical" representation of the subject is available.
- *Keyword*: contains all the keywords that refer the code present in the *code* area.
- *Query*: contains a set of fields to begin a search on the thesaurus, specifying the field to search (code, subject, keyword) and the (possibly truncated) character string to match.

Figure 2 shows how the various areas interact.

- The set of codes returned by the query stated in the *query* area fit into the *structure* area. If the user specified a code as search term, the resulting display will show a tree structure, with a maximum of four levels. In all other cases, the structure is not intrinsic to the result, therefore the resulting set will appear as a list of codes. Quite obviously, all the elements are "active" and, when mouse selected, fill the *code* area with the information pertaining to the selected node.
- The *code* area contains complete information about a single subject: notation, the icon of a representative image (if available), the subject and the keyword, both in English and Italian. Clicking on the icon opens a new browser, to display the associated image. Clicking on the code modifies the content of the *structure* area, that will display the tree having the selected node as root.

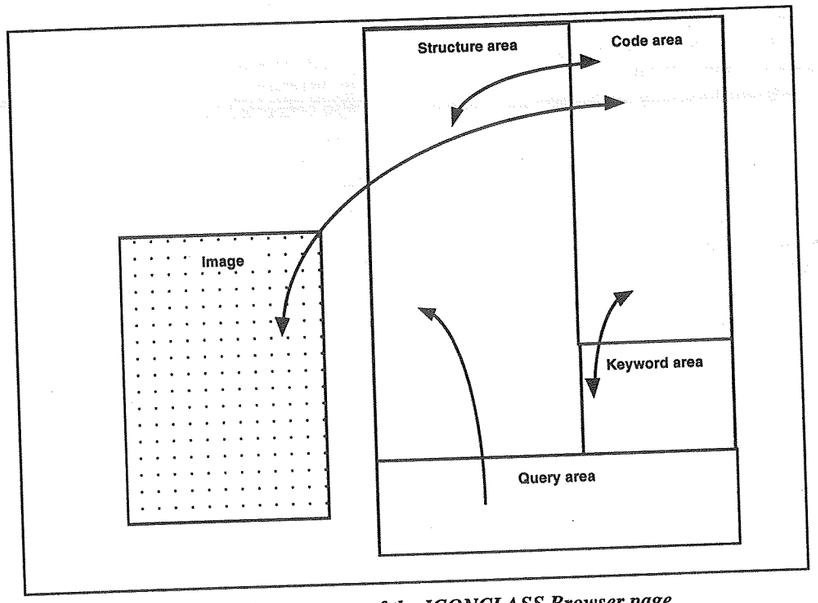

Figure 2. The Structure of the ICONCLASS Browser page

Clicking on a keyword fills the *keyword* area with the entire set of notations pointed by the selected keyword.

If the user consider a code suitable as search term, he/she can select it, just clicking the appropriate button.

- Selecting a code in the *keyword* area modifies the content of the *code* area, filling it with the corresponding detail information.

As a consequence, user can navigate both in the hierarchy and in the horizontal dimension given by the keywords referring to the subjects, so following the most suitable cognitive path.

4.4 THE DISPLAY PAGE

As anticipated, the terms selected in browsing the authority file and/or ICONCLASS can be used as search terms, and are automatically inserted in the appropriate fields of the search page. The user can modify their content and issue the query. The search/display page will show, on the left, the index of the retrieved documents. Clicking on any of them, the selected document will fill the right part of the page.

In this stage, the content of the returned document is analysed, and all the fields that, according to the "object model" defined by the ICCD, represent an explicit link to other cards (like the references of a component to the main object, or between aggregations of objects) are transformed in links. The same applies to the fields containing an artist name or an iconographic notation. They will be "hypertextualised" giving the possibility of initiating a new browsing on the authority list and ICONCLASS, independently of the values specified as search terms. Therefore, the user will be able to follow new associations, exploiting capabilities of both explicit, model intrinsic links, and potential, implicit links present in the retrieved documents.

It follows that the browsers on artists and iconography permit implementation of the cognitive layer of the hypermedia.

4.5 THE TECHNICAL ENVIRONMENT

The whole application heavily relies on a relational database, that stores data and other information, used by the application itself for several purposes like customising pages or identifying the relevant links. The database is accessed by a general purpose SQL interface. All the pages are subsequently tagged in HTML, and transmitted according to the HTTP protocol. Any manipulation occurs on the server site, so that the page can be visualised by any standard Web browser.

5. CONCLUSION AND FUTURE WORK

The progress of network technologies offers the possibility of implementing distributed hypermedia applications, but the inherent complexity of cultural heritage data is a severe obstacle to the implementation of really effective applications. Previous experiences can give a substantial help in solving availability and accessibility problems. In particular, many years of man effort have been invested in establishment of thesauri and authority files that are of invaluable help both to identify precisely concepts and terms to use in formulating the user request, and to represent the semantic knowledge on the application domain.

In this paper we described as two quite sophisticated browsers that were integrated into a generalised query interface to implement the cognitive layer of hypermedia. In particular, the ICONCLASS browser permits:

- searching terms from different perspectives;
- navigating in the hierarchical structure;
- finding related subjects;

and can be seen as a basic component of a distributed access system to Italian Catalogue data banks.

We must stress that intellectual property rights do not permit free access to the browsers. Therefore the application remains just an example of how authority files and thesauri can help in implementing the cognitive layer of hypermedia.

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