Effective Levels of Adaptation to Different Types of Users in Interactive Museum Systems

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Users interact with museum application interfaces for many reasons. There are various types of users, who want to perform various tasks, in various contexts, that can access the same Web site. Thus, it is important to have user interfaces able to adapt to these different user requirements to facilitate the accomplishment of the desired goals. Most current interfaces to museum information do not take into account this variety of types of users, thus providing interfaces that some users find confusing to achieve their goals. In this article we discuss the various possible levels of support that can be given to different users during navigation of museum information. In particular, we focus our attention on how to obtain adaptable and adaptive interfaces using the web site for the Marble Museum, which we have designed and developed, as a source of examples for our discussion of possible solutions.

Introduction

The advent of the Web has made it easy to develop hypermedia with museum information that allow a wide variety of users from all parts of the world to access them. However, little attention has been paid to the problem that usually different types of users access such information with different purposes. Consequently, it is important that user interfaces are able to adapt themselves in such a way as to better support the achievement of different goals by different types of users. Adaptation of hypermedia systems to each individual user is increasingly needed because it can solve the problem of hypermedia systems that are used by different classes of users. Users may differ widely in their goals, background, and knowledge of the topics covered by the hypermedia system. Besides, adaptation can prevent the user from getting lost in hyperspace; with the growing size, complexity, and heterogeneity of current hypermedia systems it becomes harder and harder for the existing navigational tools to provide orientation on where to search for the needed information.

The problem to provide more support to the increasing number of possible users has stimulated interest in various types of techniques. For example, techniques from the field of Artificial Intelligence, in particular so called *autonomous agents* (Maes, 1994), can be used to implement a style of interaction where the user is engaged in a cooperative process in which human and computer agents both initiate communication, monitor events, and perform tasks. Other techniques have been proposed for similar purposes. In Benyon and Murray (1993), there is an attempt to provide a unifying perspective on adaptive systems in general, ranging from intelligent tutoring to autonomous agents.

However, despite of the research efforts developed in this area, only a rather limited number of existing applications use them; this percentage further decreases if we consider museum applications. An example is in Kadobayashi et al. (1998), where authors propose an approach that allows the visitor to express the elements of the exhibition space that they are interested to navigate, and then an agent defines what they will be allowed to visit, taking into account their explicit interests and the semantic relationships among the accessible objects that the curator of the exhibition defined previously. This should support the possibility to show things strictly related to the visitor's interests even if they are not explicitly required by them. However, the examples of systems supporting adaptation are usually limited to research prototypes, and these techniques are not provided by widely used systems.

Different levels of adaptation can be identified: *adaptable* systems are systems that allow users to define some parameters of the system and then adapt their behaviour accordingly. If the system adapts to the user automatically, it is called *adaptive*. Adaptive systems tailor information to the user and may guide the user in the information space to present the most relevant material, taking into account a model of the user's goals, interests, and preferences.

Although most applications that make use of adaptive hypermedia are currently in the area of educational hypermedia (see, e.g., Brusilovsky, Eklund, & Schwarz, 1997), where it might be easier to acquire a detailed user model, these techniques might prove very suitable for the museum domain also. A museum web site can be structured to allow free roaming, but it should also facilitate learning and lo-

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cating interesting information, and, especially for this purpose, adaptable or adaptive hypermedia can be helpful. To this end it is important to take into account the studies that have been conducted to understand the way in which people visit museums and the way it is best to build an exhibit.

More generally, our work is based on the following concepts:

(1) *Limitations of designer-centered or system-oriented approaches:* often the design of interactive applications, is based completely on the intuition of the design that can sometimes fail, or it is oriented to obtain an engineered functionally correct application with low attention to usability problems;
(2) *Use of task models to support the design of a hypermedia:* task models have been recognized as a useful structured support for designer to better understand the requirements of the application considered and to design new applications with more effective user interfaces;
(3) *Design able to adapt to different types of users:* in many applications (such as museum system) the wide variety of possible users, tasks, and contexts of use to support generates a strong need for supporting different styles on interaction and different content for different users.

In this work we want to discuss different techniques to design adaptable and adaptive interfaces for museum web sites. We will also provide examples of applications of some of them by considering the type of impact that they have in a Web interface for the Marble Museum located in Carrara (Italy). Currently, the application for the Marble Museum, at the beginning allows the user to select a visitor profile (e.g., expert, art student, or tourist), and during the virtual visit the user has the opportunity to change this profile. Thus, the system is adaptable because the user can modify the profile parameter and the system changes its behavior accordingly.

More precisely, in this article, we first discuss the various possible general approaches that can be adopted to obtain user interfaces able to adapt to the different types of users considering also various adaptive techniques. Next, we describe the Web support for the Marble Museum, located in Carrara, Italy, that we have designed and developed. The publicly available version of this museum site can be classified as an adaptable hypermedia, and we show the specific solutions that have been adopted for this case. Then further possible improvements, concerning adaptive features, are more specifically discussed taking this specific web museum as reference point. The possibilities and the conditions under which this can be done will be carefully considered.

Possible Levels of Adaption

When a hypermedia is used by users with different goals and levels of knowledge, an important aspect is to support adaptation: different users may be interested in different parts of the information contained, and they may want to use different links for navigation. Most current hypermedia systems, on the other hand, do not consider the possible type of user: they provide the same hypermedia pages and the same set of links to all users.

Adaptive and adaptable hypermedia systems attempt to bridge this gap by trying to use knowledge about a particular user, represented in the user model, to adapt the information and links being presented to that user. One solution to this problem is to use the data collected on a user that are contained in the user model to adapt the information and the links that have to be presented. By knowing the goals and the knowledge of the user, a hypermedia can support users during navigation by focusing on the information provided, providing comments on the visible links, or suggesting what links are the most relevant, thus obtaining an adaptable navigation (Brusilovsky, 1996).

Generally speaking, user models can be static or dynamic. In static models, user knowledge is represented as "topic-value" pairs, but the values are not completely independent. The user can be assigned to one or more stereotypes (e.g., novice, intermediate, expert). Each stereotype is characterized by a fixed set of "topic-value" pairs, and the user assigned to a stereotype inherits all these properties. This modeling is reliable enough, and works well for a system that needs to adapt to different classes of users. In the dynamic model, for each domain model topic there is some estimation of how well the user is familiar with this topic, and this estimation takes into account the history of previous accesses to the application. In dynamic modeling it is possible to measure user knowledge with more flexibility. The static models are simpler than dynamic modeling, but less powerful. Another possibility is to combine stereotype and overlay modeling. One possible way to combine these two techniques is to use static modeling to determine the class of the user and to assign initial values for the dynamic model, then dynamic modeling is used to keep the model updated.

Systems supporting adaptation tailor information to the user and may guide the user in the information space to present the most relevant material, taking into account a model of the user's goals, interests, and preferences. Such an adaptation can occur at three levels:

(1) *Presentation*, where it is possible to differentiate the type of media, the layout, the attributes of the perceivable elements (such as font type and size) depending on the type of access;
(2) *Information*, where the information content can be changed, sometime drastically, even if related to the same topic, depending on the type of user and the use foreseen;
(3) *Navigation*, where different links are provided, in some cases in different locations and with different appearance, determining different modalities of navigation in the information available.

For example, in Brusilovsky et al. (1997), techniques to support adaptation are highlighted, and their application to the WWW context is discussed. An example of technique of

adaptive navigation proposed is interesting, because it associates links with a comment informing the user about the current state of the nodes that can be reached. The annotation can be provided in textual form or in the form of visible elements, for example, using different icons or colours or different types of fonts.

Techniques to Support Adaptation

Presentation Techniques

The idea of various *adaptive presentation techniques* is to adapt the content of a page accessed by a particular user to current knowledge, goals, and other characteristics of the user. Existing adaptive presentation techniques deal with text adaptation. Text adaptation implies that different users at different points in time may get different texts in the context of the same page. We group all these techniques into one technology that we call *adaptive text presentation technology*. Another possibility for adaptive presentation techniques is to change the layout of the page instead of the text.

One technique that is concerned with changing the text as well as the layout is stretchtext. It is one example of an adaptive presentation technique that is a special kind of hypertext. In a regular hypertext, a result of clicking on a hot word is moving to another page with related text. In stretchtext, this related text can simply replace the activated hot word (or a phrase including the hot word), thereby extending the text of the current page. If required, this extended or "uncollapsed" text may be collapsed back to a hot word. The user can override the adaptation by opening and closing any desired piece of information. A higher level technique that is based on stretchtext is suggested in MetaDoc (Boyle & Encarnacion, 1994). Each node in MetaDoc is a stretchtext page that may contain many uncollapsable hot words. The idea of adaptive stretchtext presentation in MetaDoc is to present a requested page with all stretchtext extensions that are nonrelevant to the user being collapsed, and all extensions relevant to the user being uncollapsed.

Navigation Techniques

The idea of adaptive navigation support is to help users to find their paths in hypermedia by adapting link presentations to the goals, knowledge, and other characteristics of an individual user. The most popular technologies for adapting link presentation are *direct guidance*, *adaptive ordering*, *hiding*, and *annotation* (Brusilovsky et al., 1997).

Direct guidance is the most simple technology of adaptive navigation support, and can be applied in any system that can decide what is the next "best" node for the user to visit according to the user's goal and other parameters represented in the user model. A problem of direct guidance is that it provides no support for the users who would not like to follow the system's suggestions. Direct guidance is useful, but it should be used together with a "more supportive" technology.

The idea of *adaptive ordering* is to sort all the links of a particular page according to the user model and some user-valuable criteria: the closer to the top, the more relevant the link is. Adaptive ordering has a limited applicability: it can be used with noncontextual links, but it can hardly be used for indexes and content pages and can never be used with contextual links and maps. Another problem with adaptive ordering is that this technology makes the order of the links nonstable: it may change each time the user enters the page. Recent research shows that the stable order of options in menus is important for novices.

The idea of navigation support by *hiding* is to restrict the navigation space by hiding links to irrelevant pages. A page can be considered irrelevant for several reasons: for example, if it is not related to the users current goal or if it contains material that the user is not yet prepared to understand. Hiding protects users from the complexity of the unrestricted hyperspace, and reduces their cognitive overload. Hiding is also more transparent to the user, and provides different effects from adaptive ordering where links are usually added incrementally, but not removed or reordered. However, seeing a different selection of outgoing links every time a node is visited can also be confusing, Therefore, the pages with a varying link structure must be limited and well chosen. Hiding has, however, another problem; as noted by some psychologist, hiding can provoke formation of incorrect mental models of the hyperspace.

The idea of *adaptive annotation technology* is to augment the links with some form of comments that can tell the user more about the current state of the nodes behind the annotated links. These annotations can be presented in textual form or in the form of visual cues using, for example, different icons colors, font sizes, or font types. The typical kind of annotation considered in traditional hypermedia is static (user-independent) annotation. Adaptive navigation support can be provided with dynamic user model-driven annotation. Adaptive annotation in its simplest history-based form (outlining the links to previously visited nodes) has been applied in some hypermedia systems including several WWW browsers. Even this simplest form of adaptive annotation, which can distinguish only two states of links (links to visited/not visited nodes), appears to be useful. Current adaptive hypermedia systems can distinguish and annotate differently a higher number of states on the basis of the user model.

For example, the ISIS-Tutor system (Brusilovsky & Pesin, 1994) uses adaptive navigation as a primary technique for adaptive navigation support. Isis-Tutor uses direct guidance, hiding, and annotation. In this system, the teacher can set for each student a sequence of learning goals. A goal is a set of concept nodes of the network that must be learned. Concepts that belong to the same goal are expected to be learned together and then mastered by solving a number of problems before a student moves to the next goal. ISIS-

Tutor uses two methods to adapt to the learning goal: first, to attract the students attention, it can outline links to the concepts belonging to the current goal; second (as an option), to decrease the students cognitive load, it can hide concepts that belong to future learning goals.

Adaptive annotation supports stable order of links and avoids problems with incorrect mental maps. Annotation is generally a more powerful technology than hiding: hiding can distinguish only two states for the related nodes—relevant and nonrelevant—while annotation, as mentioned above, can distinguish a higher number of states. Hiding can be quite well simulated by the annotation technology using a kind of "dimming" instead of hiding for "nonrelevant" links. Dimming can decrease cognitive overload to some extent (the user can learn to ignore dimmed links). Dimmed links are still visible though (and selectable, if required), which prevents the user from forming wrong mental maps.

Most existing adaptation techniques use exactly one of these ways to provide adaptive navigation support. However, these technologies are not mutually exclusive, and can be used in combinations. In particular the direct guidance technology can be naturally used in combination with any of the other three technologies.

Limitations of Adaptive Techniques

Although adaptive techniques can give useful possibilities as shown in previous paragraphs, it is important to note the possible drawbacks from a users point of view, for example: 1) the user does not know that the system has adopted a specific style of discourse/content of presentation and that there are alternatives; 2) the user may get confused when the system changes its behavior, because the user may not understand the reason for such a change; 3) the system can infer some assumptions from the actual user interactions that in some cases may be wrong; thus, making decisions that do not help the users at all in their further navigation.

To obtain an effective support, it is thus important to give feedback and control to the users on the choices done by the adaptive system so that they understand the criteria that drive the underlying adaptive support.

Our Suggestions for Adaptive Support

As we said before, we prefer to leave full control to the user of the adaptive support to obtain a flexible and usable environment. This can be performed in two ways: 1) the user explicitly indicates *when to activate* such a support, for example when users are not satisfied of the current information they may want to ask for further information, and the system should understand what kind of further information may be of interest in that specific context, taking into account the previously performed interactions; and 2) the system, taking into account the user interactions, indicates that *it has some suggestions* and additional information to provide, and *the user decides* whether or not to allow the system to show this information; in this case, an agent, with some rules incorporated, is included in the hypermedia to allow the system to understand how to dynamically present information (some information can be dynamically removed because the user does not seem interested in it, or other information can be added because the user seems desiring to receive more detailed information).

There are various type of information that can be dynamically provided. They can be classified in these types of information: 1) *summarizing information*, thus after presenting a series of pieces of information it can be useful to summarize the main aspects that have been considered; the system can dynamically elaborate some information depending on the data available. For example, if the user examines multiple works of the same author, it can be interpreted as a strong interest for such an author, and this can trigger the presentation of summarizing information on such an author, such as a discussion of the preferred techniques and materials used; 2) *highlighting issues*, in this case, the purpose is to highlight elements that can raise curiosity, controversial opinions, or comments from the users; 3) *comparing different items*, giving some information that can allow the user to make the comparison or to directly provide a comparison among different pieces of information; there are many types of information that can be analyzed to provide comparisons, for example, the dimensions or the period of execution of works of art, indicating what the largest or oldest are; 4) *highlighting differences*, to show how a piece of information differs from the previous piece of information considered or from a set of pieces previously considered. Another possibility is to provide information through differences with respect to what has already been considered. Thus, taking into account the history of the interaction and the related information presented the system can contrast the currently presented information with that previously viewed, while omitting any background information that the visitor has already received. This means that the system has a logical description of the information contained, and it is able to keep a history of what the user has already seen.

The Adaptable Web Interface to the Marble Museum

The hypermedia for the access to the information of the Marble Museum has been designed following a task-based approach (Paternò & Bucca, 1997).

Task-based approaches belong to a broader family of approaches called model-based approaches (Paternò, 1999; Puerta, 1997) that has raised the interest in various research sites interested in design of interactive software application. The basic idea is to use some declarative description to drive the implementation of a software artifact. An interesting approach in this direction is the Object–Actions Interface model (Shneiderman, 1997), which provides a helpful guide to web site designers in decomposing a complex information problem and fashioning a comprehensible and effective Web site.

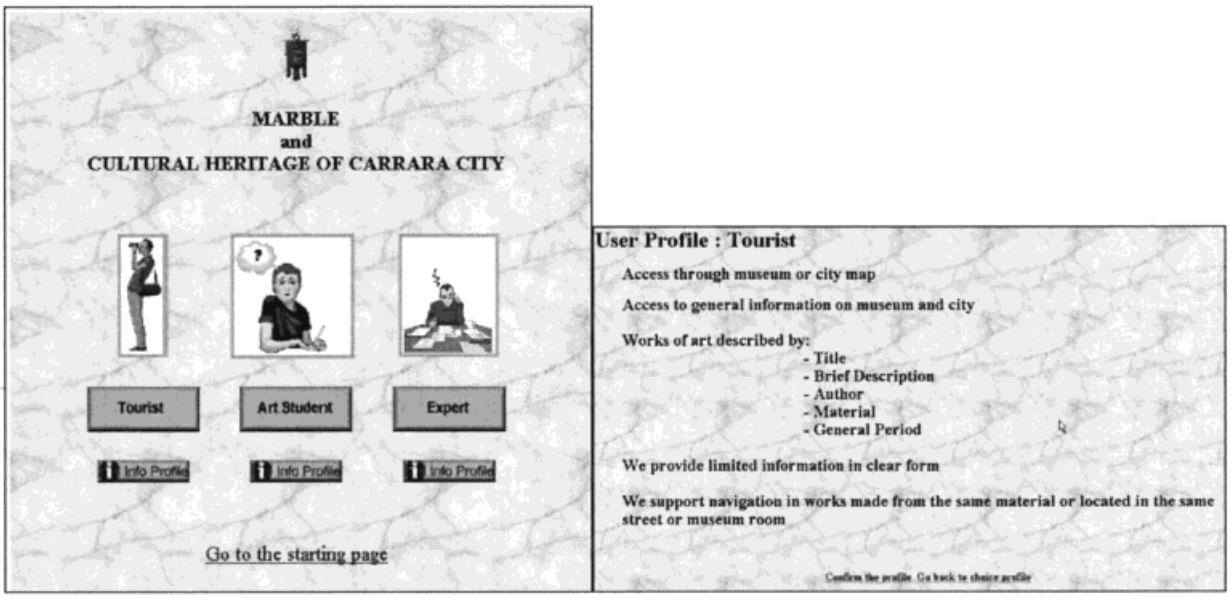

FIG. 1. The available profiles and some information on the tourist profile.

In our work, we have used task models to support the design of the interactive museum application. A task model is a logical description of the possible activities that a user wants to perform when interacting with the considered application. To obtain meaningful task models it is very important to involve in the discussion related to their development all the relevant people, in the case of a museum application: manager and employees of the museum, possible end users, artists, software developers, application designers, user interface experts. In our case, the resulting task model has been specified using the ConcurTaskTrees notation (Paternò, 1999), a notation that we have developed. It is a precise notation that provides a rich set of temporal operators, thus allowing designers to describe interactive, concurrent dynamic activities. The purpose of such a notation is to support designers in understanding how activities should evolve, and then we have developed a method to obtain a design of the user interface consistent with the indications given in the task model following some specific criteria (Paternò, & Mancini, 1999) such as task type, cognitive effort, task frequency, contextual environment, user knowledge, or layout optimization.

The hypermedia contains information on the works of arts placed in the museum, on tools that have been used to quarry and process marble, and to pieces of works located in the historical center of the town that can be considered as a natural extension of the museum, as it is particularly rich of artistic works done by marble, such as marble icons, sculptures, monuments, and so on.

When we started to design such an application we soon recognised that different types of users can have different related task models because when they approach a museum application they have different goals, different basic knowledge of the application domain, interest in different information, and so on. After many interviews to users and experts and collecting results of questionnaires distributed among visitors and potential users, we decided to group the possible users into three types: tourist, student (of art), and expert. Tourists are characterized by the need for basic general information, expressed and presented clearly. They like to access information by spatial representations (e.g., a museum or a city map) because this gives implicitly information to them concerning how to organize a physical visit. Students have a better knowledge of the application domain, so they want to access a wider range of topics, receiving more detailed information. Finally, experts want to have full access to all the information available. They need minimal support to formulate their requests, and should be allowed to formulate such requests in a flexible way. When there is a classification of possible users, it is always possible to find specific cases that do not fit in any of them, but we have found this classification suitable for most visitors to this museum.

In the design of the hypermedia we have an initial part that provides general information on the museum. It supports a few tasks that are independent from the user profile: the choice of the language and access to some general information on the museum that do not involve access to the information related to the works of art (opening time, how to get to the museum, fares), and it is independent from the type of user. Then we give the possibility to select a user profile (Fig. 1, left side). Users can access the information describing the main features characterising each user type (an example is in Fig. 1, right side). Once users have selected a profile, they can navigate in the hypermedia by the navigation styles associated with the profile selected.

The resulting hypermedia was designed according to the indications contained in the users task model. We developed three task models, one for each main type of user identified (expert, tourist, student of art). More specifically, they differ

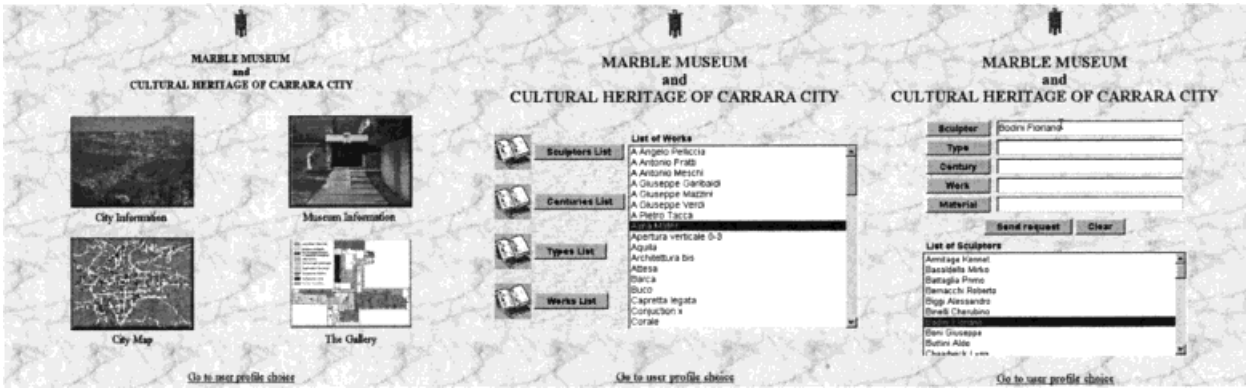

FIG. 2. The initial access for the different users.

for three main aspects that will be discussed in the next paragraphs: 1) *Initial access to the museum information*, for example, the expert can specify directly very specific requests, whereas tourists mainly access by spatial representations of the museum and the town; 2) *Presentation of the information related to the works of art*, the decision of the amount and type of information to provide and the modalities of presentation takes into account the basic knowledge of the type of users and the different tasks that they are likely to wish to perform; 3) *Navigation in the hypermedia*, which is more structured and preordered for tourists, whereas more navigational freedom is given to expert users.

Initial Access to the Information

The initial access to the information in the web museum depends on the current user profile. The expert (right side in Fig. 2) can specify directly very specific requests by directly typing values in the fields available, selecting values by lists indicating the information available grouped by sculptors, type definitions, centuries, materials, or indicating the works available, or combining both techniques (typing and selecting from list). Students can access only information by lists (Fig. 2, center) indicating the information available. Tourists can access four types of information from their initial point of access (Fig. 2, left side): general information on the town (i.e., access to the city municipal web server) or on the museum, or access to the map of the town or of the museum; this allows them to ask for information concerning works of art located in places of interest.

Presentation of Information Related to a Work of Art

As we mentioned above, different views of the same information can be possible, depending on the types of users. For example, in the left part of Figure 3, we can see the tourist view of information related to a sculpture. As you can see, the tourist users receive various support in their navigation. They can be guided to go to the next work, in this case the next work means the next work in the Modern Sculpture Section of the museum. It is also possible to access the list of all the works made by this material, the lists of works performed by using different materials (wood, bronze, and others) and the museum map, which drives the visit of the tourist in the museum hypermedia. In the case of an expert user (Fig. 3, right part) the information can be accessed more immediately (e.g., by just giving the name of the author), it is more detailed (e.g., precise dimensions and

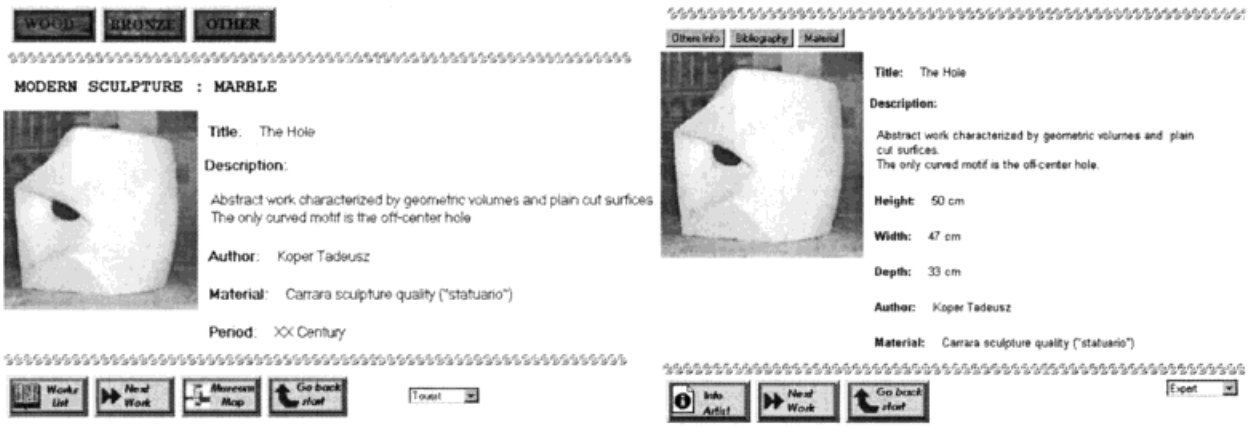

FIG. 3. An example of different views of the same information.

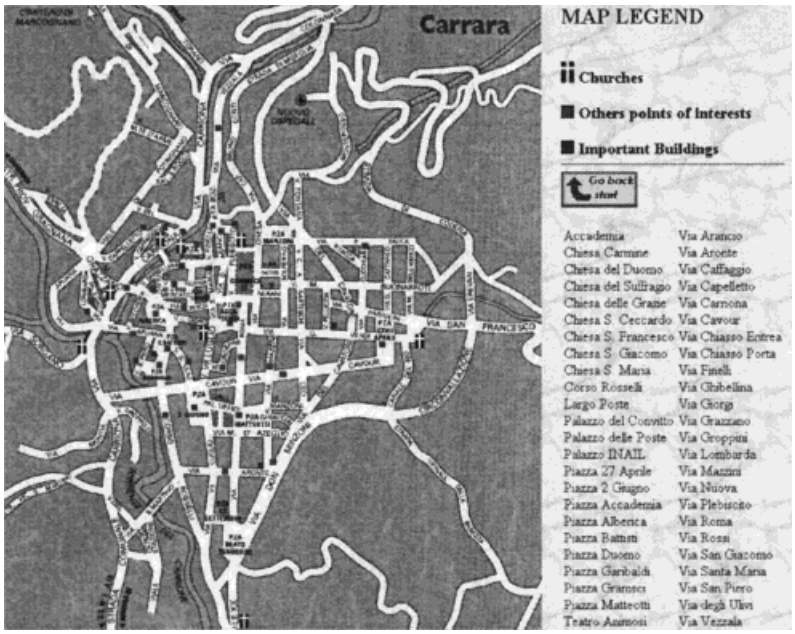

FIG. 4. The interactive map.

precise date of creation are given), and further information on the material, the author, the biography or other information can be accessed.

In Figure 3 it is possible to also see the differences concerning how the information related to a work of art is given. In the tourist case, there are less types of information available and the information given is more clearly presented with larger fonts, whereas in the case of experts users more types of information are provided, and it is still possible to immediately access further types of information. In some cases, the information for expert users is more precise, and it can be more extended.

The basic idea is that tourist users usually do not like to have an excessive amount of information that may diminish their interest. Rather, they prefer to easily get the basic and distinguishing information concerning the work considered.

Navigation in the Hypermedia

There are different styles of navigation, depending on the type of user. In the case of experts or students of art they can formulate a query (experts have a wider set of possibilities) and then navigate among the information that satisfy their requests.

In the case of a tourist, the navigation is more structured and driven by spatial representations: the map of the town (see Fig. 4) or the map of the museum. Thus, they can navigate among the works that are in a section for the museum or that are located in a street of the town. Usually such works are grouped following some criteria (such as material, type of work, and so on).

Users can change the current user profile (tourist, student, and expert) interactively at any time during the session by selecting an item in a pull-down menu, and from then on the hypermedia will show the information differently providing new ways to navigate through it. Thus, they can access the different views on the information available and the navigation styles without having to start a new application session.

Users are likely to use this feature after sometime that they use the application, because they become more competent in the field. Thus, a tourist user may want to change in the expert profile once he has some background on the topics considered, in order to get more detailed information. Another possibility is that an expert user has a very clear idea of the information he wants to access, and, in case the desired information is limited and simple, he also knows that the tourist profile can allow him to navigate and access it more rapidly.

Discussing Adaptive Solutions in the Marble Museum Hypermedia

We have found the level of support provided by the current hypermedia (available at http://giove.cnuce.cnr.it/Museo.html) for the Marble Museum satisfying because, on the one hand, users have been able to easily understand it and exploit it in their navigation, and on the other hand, they appreciate the options that allow them to have more supported access to the hypermedia.

We also performed a formal test conducted by observing 30 users belonging to the three categories. None of them had seen the application beforehand, but all of them had used a computer at least once. We tried to involve people with various levels of experience, particularly in terms of navigation in hypermedia.

The users received some written information, depending on the category they belonged to, that briefly explained what information the application allows users to access and what tasks can be performed. We explicitly asked them to communicate all the observations or comments arising from the navigation. To make the test more realistic, we decided not to provide any further information during the navigation.

The users were able to perform the desired tasks. The hypermedia was found preferable to traditional systems. It was generally considered easy to use, and some suggestions were given to introduce some additional links.

Providing Additional Support

We have developed a new prototype version of the Marble Museum Web site. In this case, we have considered the possibility provided by an adaptive solution. However, we think that a complete adaptive solution, where the system, depending on the user selection, automatically changes the type of presentation and navigation proposed, often fails to provide a usable behavior because users may not understand why the system changes its behavior and the underlying rules driving such changes can be valid for some cases but not for others. One more interesting solution is to include some adaptive features that, while still leaving full control to the user, gives the possibility to provide more dynamic support, taking into account the interactions performed by users and their preferences. This paragraph describes how we have introduced the possibilities for adaptation according to the criteria discussed previously. The main goal of these extensions is to supply the user with more support and to make the overall navigation more attractive.

The main features of the new version are:

(1) to give the user the possibility to configure a specific profile from a list of characteristics predefined that are used to support the three original profiles.
(2) To give the system the possibility to suggest changes of profiles, explaining the reasons for its suggestion, rather than changing the current profile dynamically. For example, if the current profile is the expert that gives the possibility to access additional information whenever a work of art is presented but the user never selects the additional information, then we can assume that probably there is no much interest in detailed information, and another user profile might be more suitable for the current user. Another example is when the user starts with the tourist profile but after a certain number of accesses they may be interested to get more detailed information and the system should be able at least to propose this possibility.
(3) To always have an overview of the current room present as to help the user navigate through the museum.
(4) A useful support is to give feedback of the links to nodes already visited. In the current state of the hypermedia application the works of art are viewed in circular form (once the user has seen all works, the next-work button brings her again to the first work), it is important to provide at least the simplest form of link annotation seen/unseen: any link to a page that has already been viewed should change color.
(5) There are also some possibilities for adaptive ordering. For example, in pages where a list of works is presented, works of art not visited before could be placed on top, while links to works of art already seen by the user could be placed below and have a different color. In this way, the layout of the page is changed to make navigation easier for the user without increasing the cognitive load. These link-level adaptations are all very simple, but have the power to greatly increase the user-friendliness of the application.
(6) Attention should be paid to how to support the access to the "next" page. In our case, we offer the choice of sequentially presenting the list of works grouped by author, by historical period, or by material. The order of presentation should reflect a logical order. For example, if the user is examining works of a certain author, these could be ordered by date of creation or by material. The criteria for defining an order of presentation can be established by the system or by the user, selecting one of those supported by the system. Another possible example is for the system to order the works of an artist by the number of accesses; thus, the presentation can follow the level of interest raised in end users.
(7) Another important aspect is to take into account the restrictions concerning the technical environment of the user accessing the web site. Information with high data volume (e.g., videos, high-resolution pictures) is replaced by less demanding equivalents with low-bandwidth network access (e.g., via a slow modem) to reduce download times if required. The response time of a hypermedia system is extremely critical from the point of usability.

An Electronic Guide as Adaptive Presentation Techniques in the Museum Application

One goal is to give the user the feeling he is shown around the museum by a real human tour-guide. This feature should stimulate the user to spend more time with the application and consider the application as more attractive. By referencing to works earlier visited, the presentation can be more coherent and less monotonous. We thus provide support to this possibility.

We can consider some examples on how exactly this earlier information can be taken into account. These examples are based on the works of Felice Vatteroni, using the "tourist" visitor profile. The Vatteroni donation consists of some 20 works of art. To the tourist all works of art are described using the following format:

<name>
<descrition of work>
<artist>
<materials used>
<period>

There are several dimensions on which the current work-of-art can be compared to the ones previously viewed, for example:

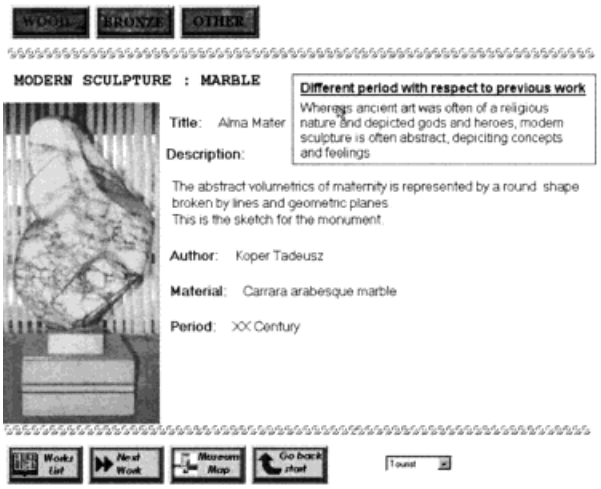

FIG. 5. Differences concerning the historical period.

(1) *Differences concerning the sculptor*, when the visitor has only seen works of other sculptors and is entering the virtual Vatteroni room, some general information on the sculptor could be included in the first Vatteroni-work viewed.
(2) *Differences concerning the material*, when the visitor encounters a work of a new material some remarks could be made about that.
(3) *Differences concerning the historical period*, when a user moves from works from one historical period to works from another, some remarks could be made about that. For example, when a user virtually enters the modern sculpture part, some remark could be made about the differences between modern and ancient sculpture.

We have identified a space in the presentation of a work of art of the current hypermedia that can be used to provide the additional information provided by the system agent that follow the above criteria. This space is located in a fixed position (Fig. 5, top-right area), and it is surrounded by a rectangle to highlight it. In the top part, there is a sentence indicating the motivation for providing additional information. For example, in Figure 5 we show an example where a user access information concerning a work of art executed in a period different from that of the previous work and some general information concerning the main differences between the periods is given.

Conclusions and Future Work

We have discussed how the design of web sites containing museum information can be improved to take into account the different needs of different types of users. We have indicated the different levels of automatic support that can be provided discussing advantages and concerns.

We have also presented the solution that we have provided in web site for the Marble Museum. We have seen that simple mechanisms supporting adaptation can be highly effective. We have shown the current solution publicly available, which is based on a finite number of user models, and we have indicated further solutions that have been developed to carefully introduce adaptive support. The new version with this additional features will be publicly available in a few months.

Future work will be dedicated to carry out a new formal empirical study on user preferences concerning techniques to support adaptive interfaces.

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