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DISORIENTATION IN HYPERMEDIA ENVIRONMENTS: MECHANISMS TO SUPPORT NAVIGATION

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ABSTRACT

The problem of navigation in hypertext is quite often associated with (dis)orientation. We begin this article by making a review of several mechanisms to support navigation after having done a brief presentation of the phenomena "getting lost in the hyperspace." To simplify and clarify our explanation we have assembled the various proposals of support to navigation into the following: 1) solutions regarding the tools to support navigation, 2) solutions regarding interface and navigation metaphors, and 3) solutions regarding hardware and other approaches to deal with this problem. The analyses made of each mechanism to support navigation intend to offer different points of view about the *pros* and *cons* of their use.

DISORIENTATION IN THE HYPERSPACE

Conklin, in his article "Hypertext: An Introduction and a Survey," considers the existence of two different types of problems in relation to the hypertext systems:

1. problems arising from restrictions to the present state of development.[1]
2. problems that seem endemic to the hypertext [1].

Due to its specific nature, problems arising from the present stage of development in the hypertext/hypermedia fields, restrictions should be considered no longer as a barrier, but as technological stages in the continuous movement of software and hardware innovations. This may lead into a predictable solution within some time.

[1] Although the article "Hypertext: An Introduction and a Survey" goes back to 1987, that isn't relevant to the importance of this remark.

The endemic problems are our main concern since they are related to the very concept and characteristics of the hypertext/hypermedia systems. Being "endemic" the solution for these problems cannot be taken for granted, and the fact of not being solved questions the usefulness and pertinence of using such kind of systems.

The navigation in hypertext, quite often associated with the disorientation problem, can be identified with this kind of endemic problems. Conklin characterized "disorientation" as the difficulty to know "(1) where you are in the network and (2) how to get to some other place that you know (or think) exists in the network" [1, p. 38]. The problems related with navigation in hypertext are of utmost importance in what concerns the potentialities of these systems. This can be realized through the multiplicity of references to the problems of navigation (and disorientation) in the specialized literature [1-19]. The "discussion of the merits of hypertext (. . .) has frequently been dominated by discussion of the efficacy with which various systems address the navigation problem" [10, p. 286].

Feeling lost, not knowing where to go, not knowing where we are, and finding difficult to select the next node of information, these are some of the problems the users must face each time they interact with a hypertext system.

Hammond and Allinson refer four problems arising from the exploration of hypermedia spaces [20]. According to them, the users:

1. Get lost in the hyperspace;
2. May find it difficult to get an overview of the material;
3. May have difficulty in finding specific information;
4. May ramble through the knowledge base in an unmotivated and instructionally inefficient fashion.

This "disorientation feeling" is bound to cause frustration, since decisions about the node or sequence of nodes to be explored are difficult to make in complex environments.

IF THERE IS A PROBLEM, HOW ARE WE GOING TO DEAL WITH IT?

"Given that there are problems with browsing, are there any solutions?" [5, p. 15]. The words of Ray McAleese we have just quoted deserve strong meditation since we believe this is a problem which needs a great deal of research until efficient solutions can be found. Tricot even considers navigation to be a fundamental matter in what concerns research among hypermedia [15].

Looking for a solution for the problem of disorientation while navigating in hypermedia documents may lead us into a multiplicity of solutions or hypothetical solutions (since their effectiveness has still to be demonstrated in most cases) all very different. The specialized literature gives information about some research in the area of navigation in hypertext, which enable us to consider more than one approach to the problem.

Tricot tries to systematize the research done on suggestions given to solve the problems concerning navigation in hyperdocuments, considering three different approaches [15]:

1. Technical solutions and interface ergonomics,
2. Theoretical approaches, and
3. Cognitive approaches.

According to Tricot, each of these approaches comprises various subdivisions, which may present a high degree of inclusion and generality while in others is very specific. On the other side, the criterion to be followed in the inclusion of a particular type of research in one of the approaches mentioned above isn't always clear. Tricot himself, for example, includes the "analogies with other navigations" in both theoretical and cognitive approaches.

Though Tricot's attempt to systematize the various ways of supporting navigation in hypermedia [15] are beyond question, we have decided not to follow him in such matters as systematization, since we believe there is much imbrication among what is defined by Tricot as theoretical, cognitive and practical approach. Furthermore, the literature is enough proof that we must consider the support to navigation in more than one perspective. It is important to have in mind that it isn't always possible to identify each proposal with a practical, theoretical, or cognitive approach.

We couldn't find any precise methodology to be followed, and thereby adopted, to characterize all the possible approaches in terms of solutions for the problems of navigation in hyperdocuments. So we have decided to organize the systematization concerning the proposals of support to navigation in a rather empirical way, following Stanton [21]. That means, we have grounded our ideas in the research described in the literature and therefore we consider, just as a means to simplify our explanation, the following ways to analyze the proposals of support to navigation:

1. solutions regarding general aspects of the interface;
   - 1.1 solutions regarding the tools to support navigation;
   - 1.2 solutions regarding interface and navigation metaphors;
2. solutions regarding hardware; and
3. other approaches regarding support to navigation.

We are aware that the assembly we have made to simplify our explanation is somehow artificial, but the sequence imposed by the physical support (paper) in use barely stands a different type of approach.

SOLUTIONS CONCERNING GENERAL ASPECTS OF THE INTERFACE

The problems of designing human-computer interfaces have been subject to numerous kinds of research and there are many periodical publications that present specialized articles in this area. The need for a design of intuitive and friendly interfaces has a very important role in the prevention of navigation problems.

Referring hypermedia systems, Jonassen and Grabinger say the "the interface user-system acts like a navigational filter that either clarifies and facilitates the use of the system or acts as an impediment, preventing effective use of the system" [8, p. 17]. Still following the same ideas, though getting support from research related to navigation in complex databases, Canter, Powell, Wishart, and Roderick also say:

> It is particularly interesting to relate navigational models to the various types of interfaces available for the control of database interaction, since interfaces can be considered as aspects of the system which help or hinder the effective navigation of the various possible states of the system, as well as influencing the nature of the navigational strategies employed by users [22, p. 249].

The worries about interface design become even greater when we think about hypermedia systems in the learning context. Allinson and Hammond, express that feeling when they say: "So we realized that if the voluntary use of an LSE [Learning Support Environment] was to be successful, then the system must be useful in extending the student's knowledge and understanding, and it must be easy to use so as not to squander the student's resources on learning the system per se" [23, p. 63].

The majority of hypermedia systems and documents are intended to give the user a high level of control and autonomy over the interaction, thereby allowing an individual form of browsing the hyperdocument. Furthermore, these characteristics of the hypermedia documents are of great importance in making them very stimulating learning environments, in a way that meet the requirements of the cognitive and construtivist psychology. The concerns related to the design of hypermedia interfaces are too relevant, because:

1. they can facilitate or turn more difficult the interaction between the user and the system and
2. they can induce or avoid disorientation during navigation in hyperdocuments.

The interface design for hypermedia systems has benefited from a pre-existing great deal of knowledge about human-computer interfaces, due to the big development and publishing these systems have been having. Nevertheless, as Hardman and Sharratt say " the sets of current HCI [Human Computer Interaction] principles and guidelines are very general purpose sets and do not specifically address the design of hypertexts" [24, p. 253]. These authors, inspired by the works of Smith and Mosier, and Brown [25, 26], which present more than 900 guidelines for interfaces design, have selected about sixteen principles that are directly applicable to the interfaces design of hypertext systems, though its efficiency has still to be proved.

The literature in the domain reports experimental research concerning interface design and its influence on the navigation process in hypermedia documents, stressing the need of an approach based in an interdisciplinary practice [27]. Graphical influence of hypermedia objects like windows is also described by Stark [28], showing the influence of different types of windows used to present additional information to the navigation in the document. As far as navigation is concerned, Stark reports that "windows style had an effect on the kind of path people took through the hypertext, although it did not affect the total amount of navigation behaviour people engaged in" [28, p. 7].

McAleese also mentions some work where the navigation strategies adopted according to the type of interface system are investigated. "There is a tendency for the graphical interface (Type 2) [consisting of node-link-node representations of the extent of the hypertext system] to encourage users to seek the extent of the knowledge/information and produce unstructured journeys, whereas, Type 1 [the card or frame with 'hot-spots' or 'active icon'] interfaces are more likely to produce browsing and scanning, where users are happy to go wherever the linkages suggest until an endpoint is found" [5, p. 14].

The references to the importance of the general characteristics of the interface in terms of navigation must be considered together with the other topics we have referred before. In fact, the types of navigation tools as well as the metaphor underneath the system design are matters intimately connected with the system interface.

Solutions Regarding the Tools to Support Navigation

Nielsen defends there are several possible solutions to the navigation problems, and presents a list of navigation tools [9]. That list comprises the following tools to support navigation:

1. backtracking;
2. guided tours;
3. bookmarks;
4. history lists;
5. navigation maps; and
6. fish-eye diagrams.

Backtracking Concept

Backtracking is one of the simplest and more usual ways of supporting navigation since the very beginning of hypertexts. The backtrack enables the user to go back again to the node most recently visited. It works like a sort of "lifeline" for the user who can do what he/she wants through the hypertext and be sure he/she's able to go back to the initial point. Since the backtracking is essential to build the user's self-confidence this must meet two conditions:

1. to be always available at any time the document is being explored and
2. to have always the same way of activation.

In our opinion, the existence of this mechanism seems very convenient since it can be relevant in terms of facilitating or giving incentive to an attitude of search by the user, supporting his/her decision of returning to the previous position whenever the visited node isn't relevant (under the user's point of view).

Research Related to Backtracking

Nielsen and Lyngbaek refer some research where subjects with experience in computing system use, mentioned some difficulties when using backtracking [29]. Nielsen and Lyngbaek suggest it is possible that some difficulty in the use of backtracking may come from the simultaneously use of several backtracking mechanisms by the system used (Guide from OLW). In addition, this system is unable to "backtrack" to the exact visual aspect of the previous screen, what causes difficulties in the orientation.

Bernstein makes also some critical remarks saying "unexpected return to a previously visited locale is intrinsically disorienting, especially when such returns are rare" [10, p. 292]. We mustn't forget that Bernstein refers to hypertext in literature, what necessarily changes the situation. The use of backtracking, in this context, is somehow compulsory [10]. In this case, backtracking doesn't depend from the user but from the system itself, which uses recursion effects to arouse a dramatic tone along the narratives.

Stanton says, " the most common form of the user action in current hypertext systems is backtracking to previous nodes. Rather than being an advantage or a desirable feature, such activity seems suspiciously like error management" [21, p. 40].

The evidence of some controversial regarding the efficiency of backtracking stresses the need of research in this area, which includes the identification of problems in the interface design or in the backtracking conceptions and mechanisms.

Guided Tour Concept

The guided tours are, perhaps, the most efficient tools of support to navigation as they can solve the problem of navigation nearly at 100 percent. Nevertheless, the adoption of guided tours means that the very characteristics of navigation in hypermedia are eliminated since they consist in navigation sequences predefined by the author (or any user). Usually the guided tours aim to give to the least experienced users, a tutorial orientation about the extension and structure of the hyperdocument.

The major disadvantage of this mechanism is the fact that represents only linear sequences of information, what goes against the principle of non-linearity, which is subjacent to the hypertext. When the documents are going to be used by novice users, we believe the use of guided tours may be advisable provided two main conditions are fulfilled that:

1. they won't be the single tool of support to navigation in the hyperdocument,
2. they will allow, at any time, to quit the guided tour for parallel explorations of the document and afterwards, if wanted, to return to the point of abandonment.

Research Related to Guided Tours

Allinson and Hammond, referring to the system Hitch-Hiker's Guide, have the same point of view expressed above:

> Though free-user-initiated selection through the network of display frames is always possible, there are occasions when a particular sequencing of information is desirable if not essential. The flow of an argument, steps in the discovery of a theory, chronological development of ideas or steps in an experiment all require sequential unraveling. Also, the novice user will require more structured guidance through the network than the experienced user. Hence we have introduced the notion of a guided tour (in the Hitch-Hiker's Guide system) [23, p. 66].

Parunak refers that a guided tour is like a turnpike map that shows the main road and indicates possible side trips for users with extra time and special interest [30].

Bookmark Concept

The existence of bookmarks is important not exactly to avoid disorientation problems but mainly to enable "recovering" from an eventual possibility of disorientation. The bookmark mechanisms allow the user to mark a node in the hypermedia document so that he can reach that node at any time during the navigation process and from any point of the hypermedia document. The user has the chance to mark nodes which seem particularly important so that he/she will be able to use those nodes as referents to which he/she can return, if he/she feels lost.

Research Related to Bookmarks

Nielsen points out, as one of the bookmarks weak points, the fact that, sometimes, the users notice but very late and only after having quit a certain node that its relevance would be enough reason to have it marked [9].

Parunak, considers that "a home button that takes the reader immediately to the entry point of the hyperdocument is a degenerate example of a bookmark" [30, p. 313], since it is usually defined by the hyperdocument's author. Taking into account this researcher's point of view, the bookmarks may either be defined by the hyperdocument's readers or authors. By this means the authors can use predefined bookmarks to suggest the readers that certain nodes are relevant for the navigation process.

History List Concept

History lists are registers of the sequence of nodes that the user looked into while navigating, and that are automatically built on by some systems. Furthermore, if these lists are interactive, they allow the user to reach directly any node previously visited.

Among the different systems there are various ways of presenting the history lists as well as different kinds of lists.

Research Related to History Lists

Paap and Roske-Hofstrand suggest that any historical list, whenever showing how the user has reached the screen where he/she is presently, may facilitate navigation. This happens because the historical list helps the user to consolidate the correct sequence of options and enables him/her to remake the path at any time, if necessary [31].

Nielsen refers the existence of history lists that include, besides the list of the nodes visited, the amount of time spent in each node [9].

The HyperCard, from Apple Company, enables the visualization of the history list as sequences of screen miniatures corresponding to each information node showing the precise sequence of the search achieved. Other systems, like the ToolBook from Asymetrix Company, build a history list, which is made by the names of the consulted nodes but where the sequence of the search isn't maintained. In ToolBook, if a given node is consulted more than once, only the first visit to the node is registered.

There are history lists, which The Electronic Document System (EDS) is an example of, that contain a history list made of miniatures of the last forty-two nodes visited, with their names, showing the time at which the access was done and respecting the exact sequence of the search. The idea behind this sort of display is to take advantage of the user's visual memory. The notion is that we might not remember the name of the node we wish to return to, but we may remember what it looked like [32].

The existence of bookmarks and history lists in the same system, allows to overcome the difficulty pointed out by Nielsen in reference to the bookmarks. Referring to bookmarks, he notices that, sometimes, the user only realizes he/she should have marked a certain node in a more advanced phase of the exploration of the document, having thus difficulty in returning to the node and marking it. This problem is made easy within the use of the history list that is automatically done by the system.

Navigation Map Concept

A great deal of the research relating to navigation and orientation focuses its attention on the graphic representation of hyperdocuments. Systems like Notecards (1986), the Intermedia (1988), and the gIBIS (1988) use graphic representations to translate their general contents as well as their structure [7]. This kind of graphic representation is presented most frequently as a navigation map. In general terms, a navigation map represents the topology of an hyperdocument, showing graphically their nodes and interactions [33-35] as shown in Figure 1.

Underlying the use of maps to help navigation there seems to be some sort of identification between the navigation in hypertext-hypermedia systems and the navigation in physical spaces. Authors like Utting and Yankelovich [32], and Recker [36] suggest that any map must give the user a spatial context, enabling him/her to realize the extent of information in the documents. However, as Stanton says, "There is some controversy within hypertext regarding whether navigation should be conceived as spatial or conceptual" [21, p. 36].

The construction of maps which represent all the nodes and interactions among them is possible only in very small documents without many interconnections (links) among the nodes. Anyhow, this kind of documents is the one where the need for supporting navigation and preventing disorientation will be less important. Beyond that, it isn't consensual that navigation maps must include all possible links, among all the information nodes. As Jones says, "a person's ability to

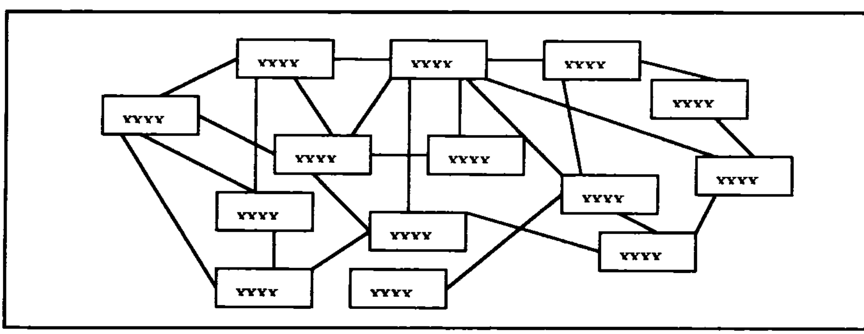

Figure 1. A possible example of a map.

use a hypertext map may quickly deteriorate as the number of units and interconnecting links increases" [34, p. 1109].

Various authors state the navigation maps may not include the graphic representation of the interactions (links) among the information nodes, since that representation shows the following problems:

1. it is difficult to show it in a single screen, for it takes plenty of room;
2. it overloads the screen with a confusing display of the links among the nodes, which cross each other in an entangled way, specially if the hypermedia application includes a high number of nodes and links [32, 37].

This opinion is shared by Boyle and Snell [7], and Stanton [38], and they even go further when they denounce as limiting, the representation of the links among the nodes. These authors also point out as a main problem of this approach, the fact that the user is bound to they way the authors of the hyperdocument view the world.

Sharing the same opinion, Wright warns us saying that a map used as orientation in a hypertext doesn't need to have the same physical appearance as a map used in a geographical context [39]. He defends that what really matters is their similar functionality. In the same line of thought, Beasley and Waugh say that "merely showing learners relationships between concepts (or that there are relationships between concepts) is probably not a sufficient condition for keeping a learner oriented within a hypermedia system" [40, p. 254].

Foss directs our attention toward the computational requirements to work out the graphic representation of a Wide Web [37]. This author also refers that, as some information Webs are intrinsically complex, a single map can't always represent their geography. Notwithstanding, our attention is directed to the fact that the cases where these situations may occur (whenever the hyperdocument include hundreds of information nodes and links) are the ones where the need for a map becomes more urgent. Nielsen considers that the solution for this type of problem may be the working out of several maps, which means, maps with various degrees of detail or to make the zoom potentialities available [9].

Besides the discussion about how to implement a map, the answer to the question of their use as a means of reducing disorientation problems, or even as a navigation mechanism, isn't entirely consensual.

Research Related to Navigation Maps

Allinson and Hammond, support their implementation in the Hitch-Hiker's Guide, arguing that "maps permit the student to see where they are in relation to other display frames and also indicate the linkages between frames. Maps can be used to 'orienteer' around the system, as any frame can be selected directly from a map" [23, p. 69]. In the case of the Hitch-Hiker's Guide, the map implemented is a dynamic one as it marks the place from where it has been called as well as the nodes previously visited.

Gay and Mazur think that, for inexperienced readers, the "availability of general visual organizers and maps, which provide a global context for navigation through the content of a hypermedia program, is vital" [12, p. 273]. These authors consider that the global context allows the user a general view of the hypertext, of its organization and extension, whereas the local context supports the user in the access to the information nodes in direct relation with its present position.

Recker has conducted an investigation where he intended to analyze the degree of interaction between students and a hypertext environment, aiming to determine the standards of utilization [36]. The hyperdocument used showed a global navigation map, which consisted in an interactive list with the most common topics of the document. The analysis of the results of this research allowed to conclude that the navigation map has been considered a facilitating, important and reliable tool for navigation in these systems. Recker states that if the hypertext environments don't supply this kind of mechanisms of help the learners they may be responsible for a user high cognitive load, able to interfere negatively in the process of learning.

Stanton, Taylor and Tweedie develop a research where the performance of two groups of individuals navigating in a hypertext system, with or without maps to support navigation, is compared in relation to the retrieve of information [41]. These researchers conclude that the navigation map didn't have any effective action either in reducing disorientation nor on the cognitive overload shown by the subjects. Stanton et al. add that "it appears that the map had a detrimental effect on navigational ability" [41, p. 442] and they suggest that the use of maps may prove prejudicial in hyperdocuments whose structure isn't hierarchical.

Sousa has conducted an investigation where she attempts to analyze the efficiency of a navigation map as a tool to support navigation in the exploration of a hyperdocument organized in a Web [19]. The hypermedia prototype developed to this study includes a map of the contents through which users could access every nodes of information. The results have been analyzed through the scores the users got in a task-test and through the results given by a program which registered automatically the interaction user/hyperdocument. The results obtained through this research show that the navigation map which has been used doesn't work so efficiently as a tool of support of navigation when compared with the maps used in physical spaces.

As we could see, some of the research results hereby shown are contradictory, what arises some questions in relation to:

1. the methodology that has been used
2. the topology and the contents of the hypermedia document under exploration
3. the aims of the research
4. the characteristics of the sample
5. the tasks given to the users.

Nevertheless, the design of an effective navigation map as a tool of support to navigation also presents some difficulties which may explain why there was such variety in the results obtained.

Fish-Eye Diagram, A Special Kind of Map

The difficulty of implementation of maps representing the whole extent of large hyperdocuments has led into investigations aiming at finding out solutions to these difficulties. In this context, the fish-eye diagrams appear as an alternative to the conventional navigation maps. Furnas [42, cited in 31, p. 277] has developed fish-eye diagrams that blend both details referring to specific places in the Web and important reference marks of the system structure. These diagrams take into account the distance between each node in the Web and the node toward which the user focuses his attention presently, as well as the nodes whose importance has been a priori defined.

The fish eye diagrams enable the global representation of the hyperspace in a single diagram, giving, though, a partial visualization of the information according to the user's own interest [9] as shown in Figure 2.

However, the implementation of these diagrams requires two proprieties from the information space: "it should be possible to estimate the distance between a given location and the user's current focus of interest, and it should be possible to display the information at several levels of detail" [9, p. 138]. Both of these

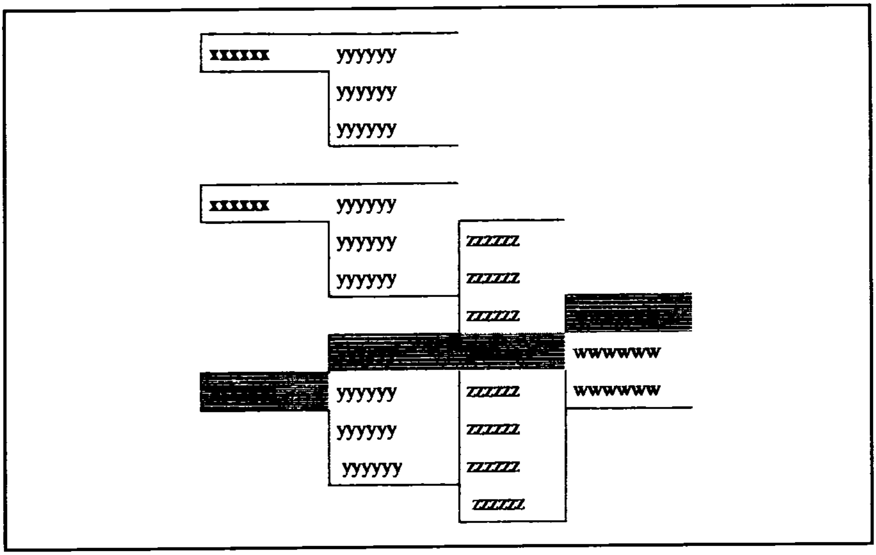

Figure 2. A possible "Fisheye view" representation.

conditions are easier to accomplish in hierarchic structures or environments with some structure than in the systems organized in a Web.

The Use of Multiple Navigation Tools in Hyperdocuments

The references done to the mechanisms of navigation support don't exhaust this theme. On the other side, at the present research state it isn't possible to be sure how efficient are or aren't the tools already referred, or foresee all the implications resulting from the coexistence of several of these tools, in the same hypermedia system.

A research conducted by Canter et al., where the influence of different types of interfaces of navigation control on complex databases was investigated, has shown that such freedom of choice in terms of interaction and navigation was bound to cause confusion, and as a consequence the advantages of each of the available options weren't explored [22].

A different perspective is proposed by Allinson and Hammond, who consider that the solution to the problems with navigation and disorientation in hypertext systems requires the implementation of a "big number of structures to have access to the information" [23, p. 66]. The same authors described the use of the Hitch-Hiker's system and reported that the four available navigation methods (hypertext links, guided tours, index, and map), have been used by 57 percent of the users, 29 percent have used three methods, and the remaining 14 percent, two methods. The same research seems to indicate that the growing familiarity with the hyperdocument theme is bound to lead into an avoidance of navigation mechanisms controlled by the system (guided tours), and instead of it, give preference to a situation of shared control (maps) or control by the user (hypertext links). However they also recommended a carefully data analysis, since these information are based upon the kind of user purpose (search of information, contents review, study of unknown material, study of partially known material, and study of familiar material), declared by the users as having supporting the selection of the different mechanisms of navigation [23].

We must also direct our attention [like 9, 12, 43, did] to the fact that, when looking for solutions to support of navigation in hypermedia, it isn't enough to choose the suitable type of tools, but it is also necessary to build on tools with a high degree of usability.

The development of research in relation to the relative efficiency of the different tools of support to navigation has also got to do with the evaluation of their degree of usability, defined by Nielsen, as linked with five parameters [9]:

1. to be easy to learn;
2. to be efficient;
3. to be easy to remember;
4. not to be bound to errors;
5. to be pleasant to use.

We mustn't also forget that, the list of tools to support navigation presented in the beginning of this article, isn't exhaustive. The uses of indexes or alphabetical lists and/or indexes of contents, preserving the organizing structure of the information in the hyperdocument, are also frequently referred in the literature.

Solutions Regarding Interface and Navigation Metaphors

Allinson and Hammond, believe the use of a navigation metaphor [2] may be a way of helping the novice user:

1. to understand the purpose and function of the information access structures
2. to help the user to easily build an internal model of the system [23].

Following the same line of thought, Baird and Percival say:

> Comparisons and analogies between the virtual world of the hyper document and the real world of everyday experience, allow users to construct a more accurate mental model of what to expect from the hypertext. Work in this field supports the idea that metaphors in general, and the travel metaphor in particular, are extremely powerful aids to navigation around complex data structures, such as hypertext systems [44, p. 82].

The travel metaphor is one of the best in what concerns hypermedia navigation [6, 20, 23, 44-46]. McAleese even says that "definitions (of hypertext or hypermedia) such as 'non-sequential browsing' are inadequate without some metaphor such as a 'journey' to make concrete the user's model of the hypertext system" [6, p. 3]. The same author adds that we can not underestimate the importance of the metaphor in realizing and facilitating understandings.

Canter, Rivers, and Storrs think, "it is fruitful to recognize the direct parallels between navigating concrete environments, such as cities or buildings, and navigating data" [47, p. 93]. These authors alert to the advantages of taking into account the analogies which exist between navigating data and navigating physical environment, what will enable us to transfer the output of some research done between navigation in the physical environment and navigation in the hyperspace. Canter and his collaborators explain that:

> One advantage of considering this analogy [between navigating physical environment and navigating data] is that there is a growing literature on how people navigate through the physical environment (. . .), which may be raided for suggestions as to the psychological processes pertinent to data navigation. There is also a developing literature on the algebraic specification

[2] It is important to refer that some of the authors of the researches described in this section, use in a somehow similar way the words analogy and metaphor. Our choice has been to preserve the original meaning of each of these words.

> of physical environmental structures in ways that have social and psychological implications (. . .). Putting these psychological and algebraic perspectives together with current thinking on the application of path algebras to interactive systems (. . .) creates a potential for a powerful onslaught on the specification and study of data-base navigation [47, p. 93].

Mahony [48, cited in 3] appears to support the adoption of a spatial metaphor by suggesting that users would not be disoriented if they had a conceptual overview (or spatial representation) of the structure of the hypertext. This author states that: "The main disadvantages of using hypertext at present seem to be consequent of its sheer lack of physical presence and integrity. The very flexibility of reading on screen is disorienting for a user who can't conceptualize an overview of the structure" [48, cited in 3, p. 106].

Researchers as Hammond and Allinson have conducted various investigations where they discuss the process by which the metaphors are used to transmit information about the design of hypermedia systems [20, 45, 46]. They say the use of metaphors enables the users to foresee the way the system works, by comparing the characteristics of this one to the characteristics related with the metaphor. Nevertheless, Hammond and Allinson also warn that, if the established correspondence isn't appropriate, the user will have to develop a bigger cognitive effort, whenever trying to infer the way the system works.

Trumbull, Gay, and Mazur emphasize the role of the metaphor, in relation to a hypermedia system, which uses the visual metaphor of the house (Victorian farmhouse) [14]. These authors say "the use of an organizing metaphor seems to have been an effective design strategy for aiding navigation and information finding in the hypermedia program" [14, p. 326]. These researchers claim the use of the house metaphor has enabled to create a context where the user could build thematic and spatial associations. They consider the house metaphor was an excellent aid to the user's navigation. To these authors, the spatial metaphor has worked mainly at two levels, since it has enabled the user:

1. to find the right path to the desired subject; and
2. to follow new paths during the searching of the hypermedia program.

Parunak emphasizes the correspondence between electronic and physical spaces, basing the description concerning the database topologies in hypermedia systems, on the strategies that are generally used in physical navigation [30]. Parunak considers humans use at least six different strategies to navigate in physical space, which may be used in the navigation in hypertext systems, mainly if these have a regular arrangement of links. Using the words of Parunak: "just as regular arrangements of streets can help travelers navigate through a city, so regular arrangements of links can help knowledge workers move through a hyperdocument" [30, p. 302].

Although the references to the use of various visual metaphors in hyper-documents are common in literature,[3] the question of using a familiar metaphor for the design of interfaces of hypermedia systems, isn't that simple.

Mayes, Kibby, and Anderson, in antagonism with the perspectives presented above, warn against the probable inadequacy of the metaphors aiming the user's spatial orientation, since they don't help the user to navigate in the conceptual space [52].

Landow goes further, even questioning the use of the word navigation in reference with the exploration of hypertext/hypermedia systems [53]. On this purpose, he argues the word navigation has a very precise analogy with:

> The art of controlling the course of a plane or a ship, presupposes a spatial world, but hypertext is not experienced as a spatial world. (. . .) In navigation (. . .) one must determine one's spatial position in relation to the landmarks or astral locations and then decide upon a means of moving toward one's goal, which lies out of sight at some spatial distance from one" [53, p. 51].

Nevertheless, Landow explains why the spatial analogy seems to be so widely accepted, supported by the following:

1. the most part of texts exists on the printed page, and is actually situated in the space and it is currently spoken, of "bringing" that text or "moving" the place of another.
2. to assume our minds work in spatial terms, through easily recalling spatial places or falling into habits of spatialization processes when organizing ideas.

Stanton even classifies the spatial metaphor as dangerous [38]. This author bases his opinion on the electronic space definition. According to Stanton, the most part of the investigations done in relation to the hypermedia environment, seems to use the word "space" with the same meaning it is used by everyday-sense where it corresponds to a physical relationship between objects. In this perspective, the electronic space would be equivalent to the physical space. Stanton, supports that, starting from the concept of hypertext as a multidimensional space, which can be explored in various ways, "space," in this context, must be defined as "the collection of objects and activities contained within a specific domain" [38, p. 288].

Stanton and Baber suggest the electronic space has its own characteristics, quite different from the ones of real space [54].

[3] We could use the references to the following metaphors as examples: the travel holiday metaphor [20, 23, 45, 46], the book metaphor [2, 49], the house metaphor [14]. the newspaper metaphor [50], and the film metaphor [51].

On the other side, and having in mind the human spatial processing and the navigation in physical environments, Stanton and Baber have noticed that, as far as these environments are concerned, people start by looking for reference points, first, and only afterwards they define the paths between those points. What happens in the hypermedia environment an impossibility of behaving in the same way, since the relationships among objects aren't stable or invariable [54].

Dias and Sousa agree with the previous point of view and suggest that "it is not wise to assume that a map that helps performance in a spatial context also form an aid in a hypermedia environment under a nonhierarchical model" [55, p. 184].

Marchionini and Shneiderman, consider that "the views and navigational tools will be easily assimilated into a mental model for a system if they are familiar" and that this thought is the ground for the use of metaphors at the interface level [56, p. 72]. However, the same researchers warn against the process of exploring a metaphor too rigidly: "it may limit the development of user's mental models for new systems" [56, p. 72]. This idea is also supported by Hammond and Allinson, who believe there is the danger that the adopted metaphors may be too restrictive.

The arguments about the *pros* and *cons* of using metaphors and analogies aren't either new or limited to the discussion of interfaces from hypermedia systems. However, in what concerns metaphors of support to navigation, it is necessary to develop more research studies, namely taking into account the influence of different factors (the user's age, the context used by the system, the characteristics of the field of knowledge) in the level of efficiency when using metaphors.

We couldn't finish without directing attention to the fact that these "virtual metaphors are not necessarily representative of all or only those structures which a given system is capable of supporting" [51, p. 128], although the metaphors used by a certain system may sometimes stand for the type of data structure, which is underneath the system.

SOLUTIONS REGARDING HARDWARE

When we talk about solutions regarding the hardware, we are accepting, that some of the difficulties the users of hyperdocuments have to face during navigation, come from imperfections of the system regarding the hardware.

Bernstein alerts to this question and he believes the problems with the first hypertexts regarding hardware are somehow responsible for the emphasis on disorientation problems [10]. To give an example, the same author refers that "some early users of Intermedia, brought books to the computer lab so they could read in the interval between pages!" [10, p. 288]; and he adds "if turning a page takes several seconds, readers may sometimes lose their train of thought while waiting for the computer to respond".[4] Concerning this subject, Lévy says it is the

[4] The readers, who are Internet frequent users, will probably reflect very seriously on these words.

system speed reaction (< one second) that allows to move almost instantaneously, from one information unit to another, what enables to generalize and use completely the non-linearity principle of hypertext [57].

Patterson and Egido studied "the impact of system response time on users' browsing behavior" and concluded that "users (. . .) solved problems faster when the system response time was fast but also that they looked at more nodes before making decisions to change the active sets of objects they were browsing" [58, cited in 9, p. 156]. They also refer the results obtained through the ZOG-KMS system (a system developed by the Carnegie-Mellon University and with a very limited time of access to the information nodes), which show that the very short period of time needed to have access to each node of information, has enabled the users to explore the system safely, since they knew it would be easy and quick to return to a previous node.

These statements on how time of access to the information nodes influence navigation, are fairly interesting, if we admit that navigation in hypermedia is a process similar to the connectionist model (of human memory). We must try to develop systems with a time of access as closest as possible to our "mental timing", so that navigation in hypermedia systems may be as natural and intuitive as possible.

It should be emphasized that only the development regarding hardware, enabling the use of much data storing devices and the access to various input and output peripherals, has made possible the development of software which gives the user a higher degree of control, as well as an easier and more intuitive kind of interaction.[5] These are conditions that seem essential, in order to develop hypermedia systems highly spread and intended for different kinds of users. Quoting Marchionini and Shneiderman "actions should be rapid, incremental, and reversible to promote a sense of mastery, control and confidence" and also "because the user points (with mouse, touchscreen, etc.) at given objects and actions, the impact of actions is immediately visible, thereby reducing errors and speeding performance" [56, p. 72].

OTHER APPROACHES REGARDING SUPPORT TO NAVIGATION

Many of the proposals of support to navigation already described, aim at easing navigation through a web where the nodes are interconnected in a relatively stable way.

There are other approaches which center their arguments not in the support to navigation through the predefined links among nodes, but instead, on the design of

[5] It is interesting to remark that, Douglas Engelbart, the inventor of one of the first biggest hypertext systems (the NLS-oN Line System) has also invented "the mouse."

intelligent hypertexts, able to generate, automatically, connections among the different nodes, based on their "semantic proximity" or "conceptual connectivity" [4].

The approach presented by Kibby and Mayes and Mayes et al. is based on research done by several investigators in the area of human memory modeling, but its development may also be related to entirely different aspects as the development of information hardware, namely regarding computers of parallel architecture [4, 52].

The position of Kibby and Mayes seems to be a consequence from the authors' saying they

> are doubtful whether the present exclusively manual methods for creating the links between elements of the hypertext will prove to be viable. Such links are more restrictive than the keywords used in many computer-based bibliographies; they present barriers to the exploration of hyperspace and are cumbersome to introduce and to manage even in small systems. They will become a limiting factor, ultimately to be rejected, in generating large hypertext systems (. . .) [4, p. 164].

The proposal of Kibby and Mayes aims the creation of "large hypertext systems in which the activation of a node (a fragment of text, a frame, a screen) will take the user automatically to the most appropriate node without the need for the link between the two nodes ever to have been explicitly coded" [4, p. 165]. These authors describe StrathTutor, a system designed to test the potentialities of the approach based on the automatic connection among the links in a hypertext/hypermedia system. In the StrathTutor "links are computed on the basis of attribute coding from a set of up to sixty attributes predefined by the author for the particular domain. 'Hotspots' of text and/or graphics are coded by attaching a subset of attributes to a particular area of the screen. Each frame can be represented as a profile of attributes, summed across all hotspots in that frame. The system computes the 'relatedness' of all remaining unseen frames to the current frame or hotspot" [52, p. 123] setting links with other nodes and this way suggesting a path to the user.

It is important to remark that Mayes et al. are not in favor of all fixed links to be avoided but that the adoption of dynamic ones enables to generate links, which haven't been unanticipated by the document's authors.

We believe this kind of approach to navigation in hypermedia systems transfers the question of disorientation problems, due to ignorance of the place where we are and the place where we are supposed to move to, into the need the user feels to try to understand what's the reason underneath the creation of a certain link. That means, "in a sense, the kind of query system approach embodied in StrathTutor turns hypertext on its head. Instead of the nodes being thought of as the units of content, the attributes in this implicit network can be thought of as the nodes and the links as the attaching of these attributes to individual frames" [52, p. 126]. In Mayes et al.'s opinion, this kind of approach may cause some disorientation due to the fact that users don't expect to have to decode the structure underneath the creation of some automatic connection. To a certain extent, this disorientation leads into a much more active learning, since it requires the user's evolvement in understanding the document implicit structure, which must have originated the creation of the link.

Another approach regarding support to navigation in hyperdocuments deals with the systems being able to create automatic links (or display information about possible links) according to the user's navigation activity.

Gay, Trumbull, and Mazur refer to a mechanism of support to navigation called Guide which, based on paths already followed by the user, suggest the exploration of different areas of the hyperdocument [59]. We should remark that, in the case described by these researchers, the system "records the path of the user—the information examined—as he/she moves about in the program" and "is programmed to determine a pattern and so note the existence of related information. If the user has not established a pattern (i.e., one not recognized by the programmed support), the Guide then suggests some areas for investigation at random" [59, p. 192]. In this sense, Mayes et al. present the suggestion of web links contextually interdependent when they say "every link is contained within one or more webs and can only be displayed as part of an active web. The learner is thereby protected from being overwhelmed by associative complexity (. . .)" [52, p. 123].

Another alternative regarding support to navigation, is the development of systems able to differentiate among the various nodes/screens that build up these environments. The differentiation of hypertext regions is a technique implemented by the creation of an explicit cognitive hierarchy. This differentiation may be obtained through the attribution of different backgrounds to the information nodes in what concerns color, structure and layout. This way, the user can get orientation all along his path, knowing where he is in the hypertext and how to move to the next region [17]. The research conducted by Nielsen shows how specifying different background designs for the presentation of nodes on the computer screen can increase the differentiability between nodes [9].

Different approaches from the ones we have been presenting here are also referred to in the literature. Unfortunately, most of them are mere suggestions still needing further research. Within the alternative approaches regarding support to navigation, the creation of "adaptive systems in which the computer is programmed to recognize user skills or information needs and then modify the interface or guide the user to the desired destination" [56, p. 79] is advised.

In other cases, the proposals favor the existence of several options regarding interfaces and navigation aids, which the user will be able to choose and modify according to his/her interests, needs and stage of familiarity with the system, adapting this last to his/her personal characteristics.

In the words of Marchionini and Shneiderman, "adaptive systems represent an attractive but unproven idea, while adaptable systems place a greater burden on the user even as they provide increased control" [56, p. 79]. In this sense, researchers like Edwards and Hardman and Kerr, warn us saying that, the existence of too many tools to support navigation may mislead the user and retard the acquisition of the more suitable mental models [3, 60]. However, the research conducted by Hammond and Allinson has shown the users learn very quickly how to use, rationally, the various mechanisms of access available to them [20].

CONCLUSION

The problem of (dis)orientation in hypermedia environments results from difficulties in access to the information we want and of a high cognitive load. We should be aware that it's sometimes difficult to build on supports to navigation without running the risk of increasing the user's cognitive surcharge or allowing an excessive control of the navigation on the part of the author (betraying the hypertext/hypermedia principles). The several proposals of support to navigation analyzed in this article mustn't be seen as isolate solutions to the problem because they can all together contribute to solve it. No single approach regarding support to navigation is going to be the best for all situations.

We have tried to analyze the main proposals regarding processes and mechanisms of support to navigation described and discussed in the literature. In this area, as in many others that concern hypermedia, there is still a lot of research to be done, aiming to enable the design of ergonomic systems in a cognitive perspective.

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