
# EXPERT SYSTEMS AND HYPERTEXT: CAN THEY WORK COOPERATIVELY?

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***Abstract***

*In recent years two technologies, hypertext and expert systems, developed independently each other, drawn researcher's attention since they seemed good tools to represent the knowledge and the reasoning process performed by human beings.*
*These two technologies, until recently, had not too much intersection between them notwithstanding both were involved in representing the knowledge of experts of some domains and the domains itseIf.*
*Also in the architecture field some expert systems and many hypertext products have been developed*
*Starting from some applications developed by our research team, in terms of expert systems and hypertext, we try here to give some suggestions about the possible interactions and the complementary use we may done of them.*

## Introduction

The concept of hypertext has been around for a long time. The dictionary and the encyclopedia are very old forms of hypertext. These can be viewed as a network of textual nodes joined by referential links. The Talmud, with its heavy use of annotations and nested commentary, the French epics such as that of Froissart who illustrated stories and loves of chevaliers by means of texts and pictures (in which he included himself in writing the chronicle of the battles) are pertinent examples.
From a linguistic point of view, Roland Barthes, in S/Z, describes an ideal text which corresponds quite precisely to the actual hypertext. He claimed: "In such ideal text the webs (réseaux) are multiple and play among them without covering each other; such a text is a galaxy of signifiers, not a structure of meaning; it has no beginning; it is reversible; it may be accessed from many entries but none of them may be declared as principal; the codes, which such a text mobilizes stand *as far as the eye can see,* are undecidable ...; of such a text absolutely plural the sensorial systems can of course get hold, but their number is never closed referring to the infinity of the language (Barthes 1970).
The original idea of hypertext was first acquainted by Bush in July 1945. He described a device called "memex" in which an "individual stores his books, records and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory." [Bush 1945]. He described the essential feature of memex as its ability to tie two items together.
In 1965, Nelson introduced the word "hypertext" (non-linear text) and defined it as "a body of written or pictorial material interconnected in a complex way that it could not be conveniently represented on paper. It may contain summaries or maps of its contents and their interrelations; it may contain annotations, additions and footnotes from scholars who have examined it." [Nelson 1965].
Hypertext systems are now appearing as a new class of complex information systems. These systems allow people to create, annotate, link together, and share information from a variety of media such as text, graphics, audio, video, animation, and programs. Hypertext systems provide a new method of accessing information unlike traditional information

systems which are primarily sequential in nature. Furthermore they provide flexible access to information by incorporating the notions of navigation, annotation, and tailored presentation [Bieber 1993].
Once more a hypertext can be imagined as an infinit electronic settling of "footnotes," each one enriching all the others, none of them secondary even though one had to be encountered first. Or it may be thought as a book's index accompanied by a pointer that would let readers wander from one reference to another without having to keep their index finger between index pages. The sequence of assimilation - associative or capricious - rests in the digits of the reader.
However, hypertext is a hybrid that spans across traditional boundaries. It is a database method providing a novel way of directly accessing and managing data. It is also a representation scheme, a kind of semantic network, which mixes informal textual material with more formal and mechanized processes. It is an interface modality that features link icons or markers that can be arbitrarily embedded with the contents and can be used for navigational purposes [Conklin 1987]. Whereas traditional databases have some structure around them, a hypertext database has no regular structure [Nielsen 1990]. The user is free to explore and combine information in different ways.
A hypertext system is made of nodes (concepts) and links (relationships). A node usually represents a single concept or idea. It can contain text, graphics, animation, audio, video, images or programs. It can be typed (such as detail, proposition, collection, summary, observation, issue) thereby carrying semantic information [Rao & Turoff 1990]. Nodes are connected to other nodes by links.
Hypertext parallels human cognition and facilitates exploration. We think. in nonlinear chunks which we try to associate with each other and build a network of concepts. When we read a book, we go back and forth a number of times to refer to previously read material, to make notes, and to jump to topics using the table of contents or the index. When we set out to write a document we first develop an outline of ideas. Then, we brainstorm, write down on paper, organize, revise, reorganize and repeat the cycle till we are satisfied with the outcome - a coherent document. In fact, we have been forced to adapt to traditional, linear text because of representation on paper.
Just as the reader of a linear document constructs a local and global mental representation of the document, the author of a linear document uses cues both at the local and at the global levels, dividing the document into chapters, sections, paragraphs, sentences, words etc. This facilitates comprehension and navigation.
Thus, both reading and writing processes emphasize a lot on the non-linear nature of thinking, a natural process in human beings. Human cognition is essentially organized as a semantic network in which concepts are linked together by associations. Hypertext systems try to exploit this basic nature of cognition.

**Some hypertext limits**

The promise of hypertext lies in its ability to produce complex, richly connected and cross-referenced bodies of information. However, it can also become a complex system of tangled webs, confusing both authors and readers. According to Conklin, disorientation and cognitive overhead are the two most challenging problems related to hypertext. He feels that these two problems "may ultimately limit the usefulness of hypertext." [Conklin 1987].
The problem of disorientation or "getting lost in space" arises from the need to know where one is in the network, where one came from, and how to get to another place in the network. In traditional text, it is not easy to get lost. There is the table of contents of topics with page numbers, the index with keywords and page numbers, and also bookmarks. However, in a complex hypertext network, with thousands of nodes and links, it is more than likely that the reader will get lost.
The problem of disorientation may be compared to the situation in which we are when visiting an old castle, attracted by the beauty of the paintings, of the sculptures, of the tapestries, we walk across rooms, staircases, passages and so on heedless of time, and at a given moment we realize that we are unable to locate ourselves in the castle being fully disoriented. Cognitive overhead is the additional mental overhead due to making decisions as to which links to follow and which to abandon, given a large number of choices. The process of pausing (either to jot down required information or to decide which way to go) can be very distracting. It can become a serious problem if there are a large number of nodes and links.
This problem is similar to that of visiting a museum like the Musée d'Orsay in Paris and, standing in the center of its immense hall from which other halls depart in which we catch a glimpse of pictures of enormous beauty, we are unable to decide which hall to visit or from which one to start.
All hypertext systems provide the basic capability of following a uni-directional link to a target node. However, the true potential of hypertext cannot be realized by this approach alone. Considerable amount of research eA'orts are underway in universities and the computer industry to develop better tools and methods to exploit the full potential of hypertext and also to solve or minimize the problems of disorientation and cognitive overhead.
In a true hypertext system, users must be able to move freely through the system according to their needs, without getting lost either spatially or cognitively. The facilities to navigate through a hypertext database must be at least as rich as those available in books.

**Hypertext and Artificial Intelligence**

Up to now, we have touched upon chunks of the classical theory of hypertext related to book representation.
But another type of hypertext is now appearing. Very often we are unable to describe human knowledge without the help of gestures, pictures, movies and so on.
This is indeed the case in the domain of Architecture, in which the beauty of a building or the shape of a fracture on the wall, or the colors of the humidity spots cannot be described without the help of icons, pictures, text, graphics, etc. Each image represents a chunk of knowledge and some parts of the image, for instance a detail or a boxed information, may recall other pieces of knowledge represented in other frames or in some text. Thus the hypertextual philosophy may be transferred to such form of knowledge representation where the problems of disorientation and cognitive overhead increase enormously, How to overcome this bottleneck?
It is clear that navigation or browsing is eAective only for small hypertext systems. For large hypertext databases like the pictorial one's, information retrieval through queries becomes crucial. Conklin had suggested that search and query mechanisms can present information at a manageable level of complexity and detail [Conklin 1987). Halasz's view was that "navigational access itself is not sufficient. Effective access to information stored in a hypermedia network requires query-based access to complement navigation..........search and query needs to be elevated to a primary access mechanism on par with navigation." [Halasz 1988].
Conventional information retrivial systems focus on keyword based automatic searching (in conjunction with Boolean operations), weighting of words based on their statistical properties, ranking of documents according to probability of relevance, automatic relevance feedback for query modification and query languages [Croft et al. 1990]. However, very few (or none) of these methods retrieve complete or accurate information. Too general a query may yield a lot of items and too specific a query may retrieve no items. Thus, traditional information retrivial is an inherently uncertain process. Combining inference techniques could eliminate or minimize uncertainty. In hypertext systems, a weighted keyword search combined with hypertext links can improve information retrivial by finding only a subset of nodes or "hits" whose links can then be followed to other semantically related nodes [Carlson 1989].
A possibility we suggest here is similar to that followed by classical Expert Systems. However, while in an Expert Systems the paths along which the user moves are perfectly controlled by the system which knows the goal to be realized, in the case of Hypertexts initially we have no information about the goal. This, in fact, is known, we hope, only to the user.
One way to solve this problem is that of endowing the Hypertext with the capability of understanding, from the path already covered by the user and from a model of the user, the goal the user tends to.

**An example**

In our opinion, the users of hypertexts may be divided into two rough categories: people looking for information about subjects contained in books, handbooks, data bases, or any written source of information, coded in a hypertextual form. In such a case the more general needs of the user are expressed in terms of natural language and this implies the possibility for a browser of interacting in the same language i.e. the browser should have the capability of "understanding" natural language. But this is one of the hitherto unsolved problems of the Artificial Intelligence.
In the second category we may collect all people who are expert in some domain and for whom very large specialized hypertexts are available. This is the case in which we are interested too.
As an example of expert domains we consider buildings located in historical centers, for which actions of recovering and/or managing must be performed.
Working in strict collaboration with a group of architects of the Second University of Naples, we implemented a hypertext by means of which it is possible to navigate through information about the history, the environment, the technology and so on (Amirante 1994).
In fig. 1 we show only a part of the graph representing nodes and links. It is evident that if the system is consulted for instance by the owner of an apartment, he might be interested in the history of the building, the dimensions of his apartment, the management or administrative constraints he must comply with in case the apartment needs recovering actions, and so on. In contrast, if the visitor is an architect charged of a recovery action on the apartment or the building as a whole, he will navigate through the technological or the structural or the environmental sections of the hypertext, following paths related to the problems he must solve.
In such a case, one may endow the hypertext with an "intelligent interface" at each node of the graph so that, on the basis of the path followed up to that node, the user is presented with the most useful choice for the next step.
Some authors studied the possibility of introducing such smart agents in a hypertext, and the most common solution has been that of using rule based systems interpreting the needs of the users and, on the basis of deductive inferences, producing the required answers (Lashkari 1995).
It should be evident now how strictly related hypertexts and expert systems may be. In fact, for analysis methodology, knowledge representation and inferential techniques, the results obtained in the field of expert systems may be adapted to "intelligent" hypertexts. Furthermore, also the studies performed in the field of user modeling in terms of AI methodologies might be applied in better refining the smart agents associated to hypertextual nodes.

One serious problem may jeopardize the applicability of those methodologies, i.e., the number of rules to explore at each step of the navigation. In general this number may be very high and the computation time required to obtain an answer prohibitively large. In order to address this sort of problems, we have developed a neural-net-like system which gives the same answer as the simulated expert system, but dramatically decreasing the number of computational steps, since computations are performed via a parallel elaboration (Aiello 1995).

## Conclusion

In conclusion, while we can confidently claim that the hypertextual technique will probably come to permeate many human ways of expression (from books to art exhibitions, from television to internet), only if a pinch of intelligence is given to it one of the biggest cultural revolutions will take place.

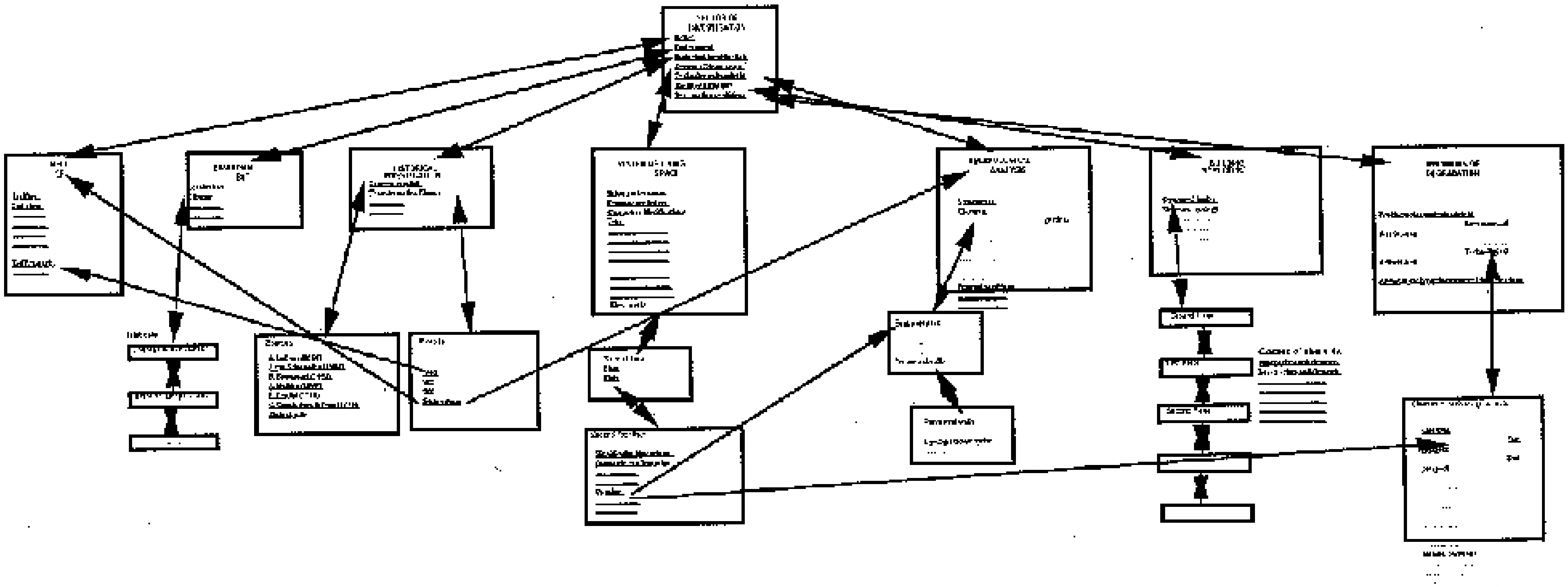

Fig. 1 - A partial graph of the hypertext of buildings of historical centers

## References


Aiello A., E. Burattini, G. Tamburrini. 1995. "Purely Neural, Rule-Based Diagnostic Systems. Part I: Production Rules", *International Journal of lntelligent Systems,* to appear, Wiley ed.

Amirante M.I., A. Bosco. 1994. "Knowledge Organization for Pre-Industrial Building - An Hypertext for Diagnosis", in Moroni & Sartori (ed.), *Dealing with Defects in Building,* Proc. Varenna, BE-MA Ed. Milano.

Barthes, R. 1970. *S/Z.* Paris: Editions du Seuil.

Bieber, M, 1993. "Providing Information Systems with Full Hypermedia Functionality". *Proceedings of the Twentv-Sixth Hawaii International Conference on System Sciences.*

Bush, V. 1945. "As We May Think, The Atlantic Monthly". July 1945.

Carlson, P. A. 1989. *Hypertext and Intelligent Interfaces for Text Retrieval, The Society of Text.*. MIT Press.

Conklin, J. 1987. "Hypertext: An Introduction and Survey". *IEEE Computer*, September.

Croft, W. B., N. Belkin, M.F. Bruandet, R. Kuhlen, T. Oren. 1990. "Hypertext and Information Retrieval: What are the Fundamental Concepts, Panel Discussion". *Proceedings of European Conference on Hypertext, ECHT '90,*

Halasz, F. G. 1988. *"NoteCards: A Multimedia Idea Processing Environment, Interactive Multimedia"*. in Ambron, Sueann and Hooper, Kristina (ed). Microsoft Press.

Lashkari Y, M. Metral, Maes P. 1995. "Collaborative Interface Agents". Tech. Report. MIT Media Laboratory.

Nelson, T. 1965. "A File Structure for the Complex, The Changing and The Indeterminate", ACM *20th National Conference.*

Nielsen, J. 1990. *Hypertext/Hypermedia.* Academic Press.

Rao, U., M. Turoff. 1990. "Hypertext Functionality: A Theoretical Frameivork", *International Journal of Human-Computer Interaction.*

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