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A hypermedia information system for the diffusion of telemedicine services

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Abstract. Since telemedicine is still developing as a discipline, information on research, on pilot applications and technologies needs to be widely diffused as do the results obtained in different health care contexts. In this paper we present a hypermedia system which offers information on teleassistance and telemonitoring taken from different sources and media. Criteria chosen in structuring the information and the basic functions of the prototype developed are described. In the last part an example of a working session is presented.

1. Introduction

Telemedicine can offer many advantages in terms of optimisation in the use of health care resources, improvement of services and reduction of management costs. The Italian Ministry of University and Scientific and Technological Research (MURST) has considered telemedicine a strategic sector to be encouraged by supporting both research programs and pilot applications. In 1995 MURST has set out a three year National Plan of Research and Training in Telemedicine with a roughly 50 MECU budget. The growing interest for this sector has produced an increasing amount of documentation. For this reason it is necessary to transfer the results of researches and experimentation, to diffuse information about national and international projects, and about the advanced technologies used in telemedicine.

Our aim is to provide a tool able to access to heterogeneous information originating from different contexts, information sources and media for users with varying interests and cultural backgrounds. The use of a hypermedia is the best solution because it facilitates the access and retrieval of information contained in texts, graphics, audio, video, animation and it permits the integration of media in a single communicative object [Ant93]. Through hypermedia systems it is possible to link the elements of knowledge of each document and create a logical structure which can be different from the author's original conception. In this way the user is not obliged to follow the linear structure of the text and can choose to tailor his/her reading according to his/her mental attitude and information needs. This is more evident when different types of documents and media (text, images, audio, video) are integrated in a new logical and structural view. This enriches the amount of information given and emphasises a personal and flexible approach to access and retrieve information. We have focused our attention to teleassistance and telemonitoring [Pis95] because of their increasing importance.

In fact there are many attempts to plan and organise health care structures based on telemedicine which may produce quality improvement of health care services as well as cost reductions. In this paper we present a hypermedia system which offers information on teleassistance and telemonitoring taken from different sources and media. Criteria chosen in structuring the information and the basic functions of the prototype are described. In the last part an example of a working session is presented.

2. Analysis and conceptual organisation of information

Most of the hypermedia products available on the market are based on the conversion of highly structured documents into hypertext form. Encyclopaedias, dictionaries and law reports already have some of the features typical of a hypertext. In fact these types of documents have different types of indexes (tables of contents, alphabetical indexes, indexing by subject and/or keywords) which constitute possible points of information access. Moreover the text itself usually contains cross-references and "see-also" *markers* which already create links with other parts of the text. In our case we needed to collect and spread information on health care

services related to telemedicine and in particular teleassistance and telemonitoring, available on different information sources. The core of information was taken from several chapters of a book [Tel93] reporting on the state of the art of telemedicine in Italy. We also consulted various sources and selected information from specialised Italian journal articles, brochures describing technical characteristics of software and devices used in telemedicine. This information was available on paper, magnetic and optical media and had different formats.

Given the diversity of the information sources and of the types of documents selected, an essential part of the work is dedicated to information analysis. This analysis requires an interpretation of the different documents from a semantic point of view. It consists in the subdivision of the documents, in the identification of information atoms and logical links among the different information atoms.

2.1 Semantic networks

This analysis aims to define a semantic network able to represent the information and the knowledge contained in the different types of documents (texts, images, audio, video). Such a network is a fundamental factor in improving the level of flexibility of accessing and navigating a hypermedia. It is composed of nodes representing the concepts (information atoms) and of edges representing the logical and semantic relationships between concepts.

Through the semantic network users are able to retrieve and navigate the information. In this semantic network we employ some relationships which are generally used in conceptual modelling, such as the relationships of *specialization, classification* [Bat 88], *is-equivalent,* [Ago94]. In order to better represent our application domain, the relationships of *benefit from, use* and *employ* have been introduced. Moreover, three concepts have been identified which are the kernel of the semantic network (fig. 1): users, services, technological devices.

The cardiac, dialytic, impaired hearing patients, etc. constitute *specialization* (sub-classes) of assisted people, who are a sub-class of users. These types of users benefit from cardiac, dialytic telemonitoring services, which are sub-classes of telemonitoring. Each of these services *employs* technological devices, for instance cardio-telephone, "Cardiobip" device in the case of cardiac telemonitoring service. Between the class of users and the class of devices there is a *use* relationship.

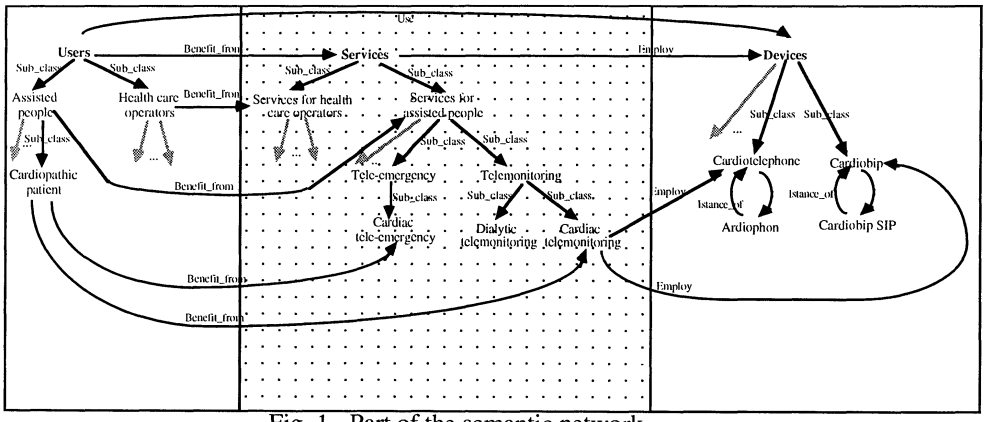

Fig. 1 - Part of the semantic network

Moreover, the *is-equivalent* relationship has been adopted in order to express the relationship between synonyms, acronyms, etc. The semantic network, aims to support the retrieval of information. It has the following characteristics:

1) each concept of the network is one of the possible access point to information;
2) the required information is retrieved navigating within the network of concepts, i.e. moving from one node to the other until the node containing the desired information has been found;
3) the navigation is constrained by both the direction of the network path and the starting node of the information search. Fig. 1 shows the arrows, which are the possible path

directions of the graph visit. They constitute a logical and semantic guide to the information search and reduce, at the same time, the disorientation of the user.

2.2 Information units

As already mentioned above, the information analysis has required the fragmentation of the different types of documents in order to isolate units with autonomous information content.

These units are called *information units* . Each information unit has been identified by a self-explanatory title, which summarises its content and indicates the way in which the subject is treated. The titles of the information units have been organised in a index which constitutes one of the access key to the hypermedia (Index of information units).

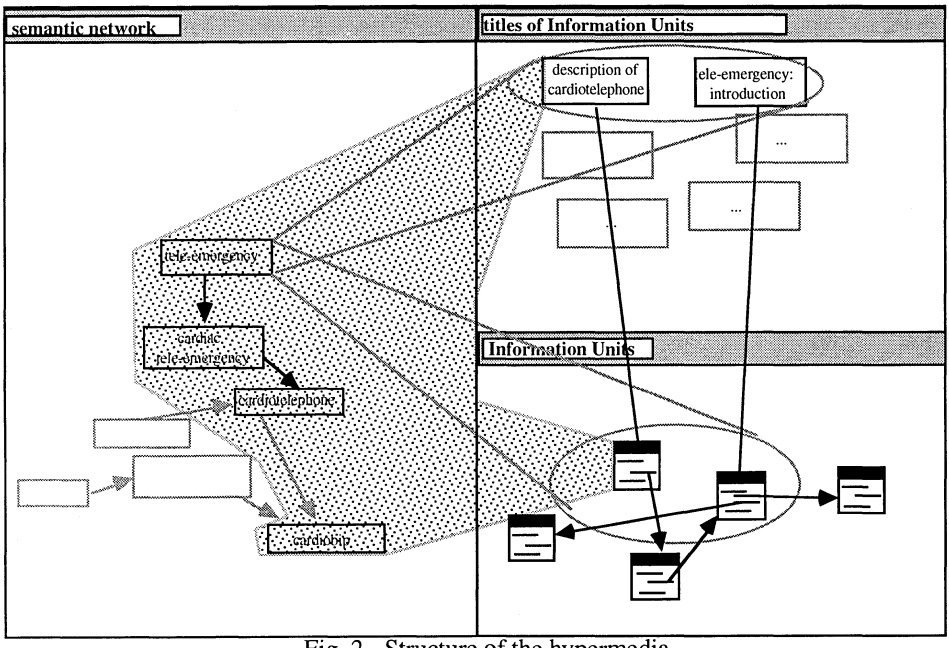

Fig. 2 - Structure of the hypermedia

A very important question in fragmenting a document is the so called *level of granularity*, that is the degree of detail in the subdivision of the information units. This subdivision has to take the following aspects into account: degree of specialisation of the information taken as a whole and in its specific parts as well as the user model to which the system is addressed.

Another characteristic of hypermedia is that of building links between information units, permitting navigation within a document and/or between different documents. It is necessary to identify meaningful points (anchor points) within a specific information context, which represent both the starting and the ending point of an information path. They are similar to the cross-references of traditional texts. Between these links there is a 1:1 relationship (see Information Units of fig. 2). Here too, the identification of the anchor points has to be based on the information paths users are likely to choose. The users are also given the possibility of displaying the full text of the document in order to contextualise it according to the author's original conception and to the graphical layout of the document. That is why the tables of contents of the book, the titles of journal articles, images, etc. constitute an index, which is another access point to information. In brief, fig. 2 shows: the semantic network implemented in the system as index of concepts, which constitutes an access point to the information; the set of titles given to each information unit, which has been implemented in the system as index and also constitutes an access point to information; the set of information units and how they are related. Concepts have a m:n relationship with the information units and with the related titles. Each title, on the other hand, identifies only one information unit.

3. The prototype

The phase of analysis and conceptual organisation of information was focused on identifying and defining various access points to information (index of concepts, index of information units, index of documents) as well as information paths tailored on the user skill.

However, a complex network of connected information units may confuse the user and produce a loss of landmarks. This is a challenging problem of hypermedia systems, known as disorientation and cognitive overhead [Con87]. The first one arises when users "get lost in space" and are not able to understand where they are in the network, where they come from, and where to get to. The problem of cognitive overhead refers to the decisions the users make when they have large numbers of alternative information paths.

We will now briefly describe some of the functions developed in the prototype in order to overcome these problems. They are: MAP, RECENT, BACK, BOOKMARK. The MAP function graphically shows the state of the system, displaying the type of information which the system is processing. The RECENT function allows the user to return to nodes which have already been visited without necessarily following a sequential path. The BACK function, on the other hand, allows backtracking to the most recently consulted path. The BOOKMARK function allows the user to memorise the access points to areas of hypermedia which need to be accessed directly in successive work sessions. This greatly reduces mental overload during the consultation phase, speeds up interaction with the system, and makes it more pleasant to use. An effective interface should be characterised by maximum ease in the use of the system. Since different users have different needs, visual communication probably represents the best way to overcome cultural and linguistic barriers. For this reason the prototype has been provided with an icon and menu based interface which is more immediate and more pleasant to use.

3.1 Working session

The first screen of the prototype gives three options: general index of document titles, an index containing the titles of the information units, the index of concepts. If the first index is selected, the complete list of documents is provided. Selecting the title of the desired document, for each selected document it is possible to access : the index; the index of the titles of the information units; the index of the concepts; the full text. If the index of concepts or the index of the information units is selected, the access to the related information units is provided. Within each information unit it is always possible to find all the concepts present in that document, to gain access to the general index of concepts available in hypermedia, to gain access to the general index of information units, to reach the index of the document and thus the chapters and paragraphs which compose it, to gain access directly to the beginning of the full text of that document. We describe an example of a working session. Suppose a cardiopathic user who wants to know which services exist for his pathology. From the first screen of the prototype (fig. 3/a) he can choose the index of the information units (fig. 3/b).

The system can show the related information unit (fig. 3/c). In order to widen his search, he can access the index of concepts (fig. 3/d) where he can find under *"Cardiac telemonitoring services"* the devices employed by this service, for instance "cardiotelephone". The selection of this concept allows him to view the information unit containing the technical and commercial description of this device (fig. 3/e). Selecting the anchor point he can activate the link to the image of the cardiotelephone (fig. 3/f).

4. Conclusion

Compared with other tools of data organisation, the particular advantages of hypermedia lie in the flexibility of information access and the possibility of non-linear consultation of documents. Since we intend to provide users with an updated state of the art in telemedicine, we have designed and implemented the prototype in the perspective of developing an open system.

The evaluation of the prototype was carried out by a group of physicians from the Università Cattolica del Sacro Cuore in Rome and by a group of ISRDS researchers. The prototype was developed using the tool PLUS 2.0 on both Macintosh and IBM platform.

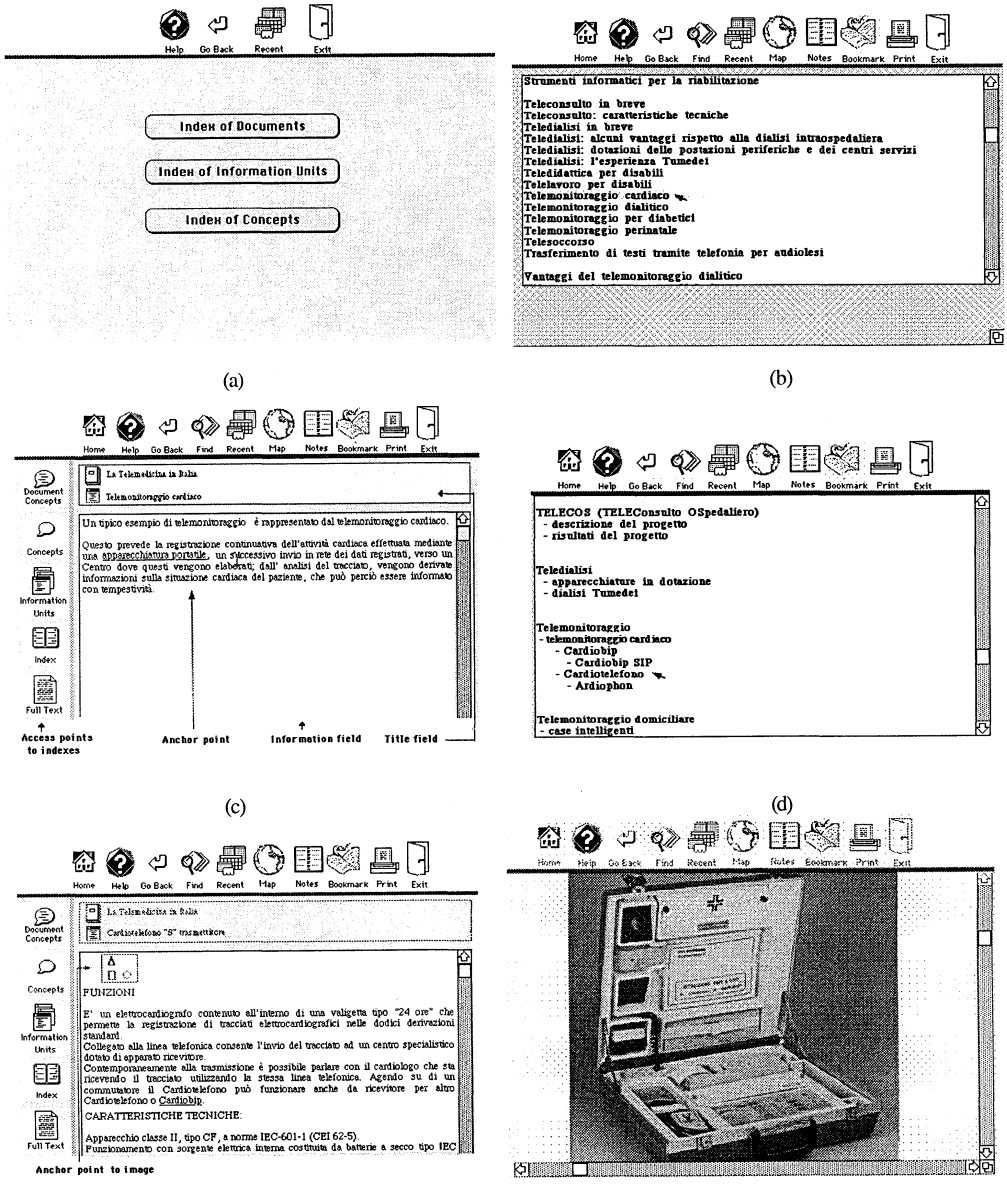

Fig 3 - Example of a working session

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