Medical Informatics Europe '96
J. Brender et al. (Eds.)
IOS Press, 1996

An Experiment towards a Document-Centered Hypertextual Computerised Patient Record*

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Abstract. The use of computerised patient records (CPRs) is dramatically subject to physicians' acceptance. A hospital wide study of users' requirements, as part of a European project, led to a document-centered approach to CPR, where efficient and relevant access was emphasized. Current WWW technology facilitated the rapid test of the proposed functionalities. From an actual paper patient record, the result is a mock-up of a hypertextual document-based patient record, enhanced after physicians' feedback, and design directions.

1. Introduction

A central element in recent medical informatics developments has been the Computerised Patient Record (CPR). CPRs tend to be highly structured (*e.g.* [1]) to enable sophisticated exploitation of medical data. But this approach had been considered to be too restrictive, in terms of medical expressiveness, to replace the current practice of health care actors mainly based on free text reports [2, 3]. Besides, another challenge for the CPR is to provide easy and consistent access to patient information which is comprehensive, credible, accurate and relevant, and to provide this information at any time and at the place of care, consistent with standards of patient confidentiality. In this respect, the paper-based patient record (PPR), though imperfect, exhibits in practice properties that facilitate physicians' reading [4, 5]. It seems desirable [6] that such features are taken into account for the CPR to be accepted when designing user interactions.

Within the DOME project, an exploratory study for RTD work, we have carried out a study to design a document handling system for use in the health care environnment. The originality of the DOME study, conducted at "la Pitié-Salpêtrière" hospital (Paris, France), has been to design a target system which is not technology driven, but which addresses the global end-users' needs of computational aids for the production and the processing of medical reports. Health care professionals were involved in the specification of an ideal system which is best described from a user point of view as a multimedia, hypertextual document-based CPR with browsing facilities. From an actual PPR and using World Wide Web technology, we developed a CPR mock-up which was assessed and refined after several demonstrations.

2. Market Survey at the Pitié-Salpêtrière Hospital

2.1. Methods

The Pitié-Salpêtrière hospital is one of the largest hospitals in Europe. In this huge institution, a market survey has been conducted to assess the present situation in terms of medical

*This work has benefited from the financial support of the European Commission's Telematics for Language Engineering programme (project DOME, MLAP contract #63-221).

reports production and processing, and to elicit from clinicians the ideal document processing environment related to CPR.

The survey has been carried out by means of personal interviews and document analysis on 36 departments. Around 150 persons including both doctors (residents, senior residents and heads of departments) and secretaries have been interviewed about their current practice in handling patient medical records. On the basis of an analysis of these data, we were able to specify a first synthesis of users expectations. In addition, intensive discussions were held with representatives from various segments of the user group covering a wide range of medical specialisations. After initial open-ended brain-storming sessions, later sessions worked on the basis of a mock implementation of the emerging system.

2.2. Results

The study revealed that French clinicians operating at the Pitié-Salpêtrère hospital are rather satisfied with the currently used PPR. Compared to an unstructured "basket" that contains everything about a patient medical history, it is flexible enough, from the writer's point of view, to allow freedom of expression concerning what to record, to which level of detail, and how to describe it. From the reader's point of view, there is no consensus about the browsing capabilities of the PPR. The lack of organization is considered either as a weak point for data retrieval under time pressure, or as a strong point for data mining in an exploratory way that respects personal habits and specific requirements of medical specialities [4]. Nevertheless, information technology has changed the culture of the working environment dealing with the care of the patient. Nowadays, the clinician is not alone operating with the patient and workflow constraints should find a solution with the computerisation of patient records. In this context, physicians have expressed the wish of having an overview of the complete medical record on one or two pages (screens) with the last conclusions as well as alerts that should not be missed. Then, when clicking on a word summarizing some episode of the medical record, it should be possible to retrieve all the documents of the complete record describing that episode. This approach allows to combine the two opposite facets of the medical record, synthetic when clinicians need to have an overall idea and exhaustive with the legal requirement to provide users with all the available information when developing a specific item.

3. A Mock-Up of Hypertextual CPR

3.1. Design Philosophy

The driving idea is to consider the CPR not as a collection of patient related medical data that can be fairly and in a useful manner presented to the user, but rather as a collection of documents that primarily mimics the PPR. These "base" documents are strictly conformant to those health care professionals actually use in their daily practice. These include external documents related to the patient, not only those produced during current hospitalisation. The patient record is primarily a collection of multimedia documents.

The goal on which we primarily focused was to suggest synthetic presentations of the various documents the actual PPR consists of, and that would satisfy the users. These presentations through "synthesis documents" aim at facilitating an easy acknowledgment of, and fast access to, the medical content of the patient record in an exploration mode suited to their current practice in hospital department, *i.e.* according to the discipline, and even to the department, or the user himself. Such a requirement also implies that several access paths across the patient record are permitted. That is why a hypertextual approach has been adopted.

3.2. Implementation

The development technology we used is based on the web philosophy and tools [7]. Each document corresponds to a HTML page that is either served or generated on the fly. They can therefore be browsed through any available browser, which constitutes a client user interface. Access to other documents is simply realised by mouse-clicks on sensitive areas in the presented document. The mock-up presents an actual patient record in rheumatology for consultation. A great part of the original paper documents have been keyboarded and consistently anonymised. They are presented in a form as close as possible to their paper version. The mock-up contains more than one hundred base documents (texts, reports, images, raw data) covering 8 years of a single patient care.

3.3. Base Documents

Base documents were categorised according to medical criteria. On one side the patient discharge summaries (PDSs) from previous hospital stays, on the other side the examination results where image and paraclinal data are distinguished.

Whatever their originating department, every PDS follows "almost" the same plan. Some information is invariant (originator: author/department/hospital, destination, date, etc.). The rest is made of semi-structured text with typical sections (reason for hospitalisation, antecedents, history, conclusion, discharge treatment, etc.) containing arbitrary free text paragraphs. This structure is coded in the text with specific SGML-like mark-up.

Laboratory results were categorised according to the kind of test (blood gas, bacteriology, urinary tests, etc.), image data according to the investigation mode (invasive, radiology, echography, scintigraphy, etc.). Each base document contains some test identifier in addition to the same invariant information as for PDSs. Raw data are essentially presented in tables.

3.4. Synthesis Documents

A synthesis document is expected to provide the reader with a fast and pertinent account of the PPR contents, of one document, or of a set of documents. Most syntheses are up to now virtual documents which do not have their paper counterpart. Such syntheses are summaries that may be either derived from the structure of documents, which also reflects their informational contents, or written by physicians (*e.g.* problem list, follow-up notes).

Document Summary. Single document syntheses are used mostly for textual documents for which they provide a summary. They are based on their internal tagged structure and are automatically generated. The most relevant information is presented without details. Basically, a PDS summary reports the authoring context (date/author/...), the "reason for hospitalisation" section, the "conclusion" section, and the plan of the original document.

Aggregation. Syntheses can also be produced for several documents from which they aggregate information. The first kind of useful synthesis that gives an overview on some part of the patient record is the table of contents, or catalog. Catalogs provide a list of documents (and access to them) sharing common properties. The first catalog is the complete chronological list of base documents of the CPR which is lacking in the PPR. Each document is refered to by its date, type, origin. Other catalogs may be generated from various user criteria. Raw data issued from multiple similar tests can be aggregated over a period of time to provide a synthetic view on the evolution of clinical parameters. Graphical accounts of such data can be presented in connection with the nursing record.

Global Syntheses. The whole patient record syntheses are supposed to provide the reader with immediate critical medical information. Such syntheses documents are typically based on the informational contents of all the other documents in the patient record, but not on their

structure (though it could help). These documents could be extracted by contents analysis methods applied to existing base documents, and/or elaborated by physicians. The "**medical card**" as the first document presented to the user constitutes the "cover" of the CPR. It contains a short list of significant medical information about the patient: (i) alerts that should not be missed; (ii) the reason for hospitalisation; (iii) the main known diagnosis; (iv) the extracted conclusion of the last previous PDS; (v) a synoptic graph (calendar) of previous hospitalisations from which the correponding PDSs can be accessed; and (vi) pointers to other relevant synthesis documents. The next important medical document is the "**synthesis of current hospitalisation**" . It contains mostly full text and is structured like a PDS. This synthesis is the dynamically evolving draft version of the PDS to be written at discharge. The "**antecedents list**" collects all the patient past pathological events. It may be based on standardised medical terms. Several listing criteria are proposed: by type (medical or surgical) or by chronology. The "**disease history**" page, though different by its content, adheres to the same design principles.

3.5. Navigation through the CPR

Seeking information among huge amounts of documents is an important issue. The mock-up offers three means of access to the documents (or parts) of the CPR. Though each access is obtained in nearly the same way (*i.e.* by a mouse click on an anchor), the underlying motivations and methods are different and do not serve the same information retrieval strategy.

Structural Access. Structural access relies on the invariant structural properties of documents. Basically, catalogs provides comprehensive lists of various documents according to their type (PDS, radiology reports), at different levels of genericity (*e.g.* documents>test results>blood gas results) or to some characteristic (same originating hospital). The table of contents of textual documents reflects their structure and provides access to its parts.

Hypertextual Access. Hyperlinks relate some textual portion of a document with another document or a part of a document. Such links are based upon semantic relations in the medical context that are not reflected by the document structure. Typically, an expression in a text, considered as a reference either to another document (*e.g. "Coronarography practiced on Jan 15."*) or to a clinical episode (*e.g. "Septicaemia"*), is the origin of a link. The corresponding link destination is expected to deliver more detailed information; it is either a whole document (*e.g.* the coronarography report) or a selected part (*e.g.* the paragraph describing the septicaemia episode in the appropriate PDS). In the mock-up, hyperlinks have been set-up in most of the textual synthesised documents with the help of clinicians. Expressions using relevant medical vocabulary are link origins enabling a direct access to original information, thus providing finer grained information and context.

Dynamic Search. Full text retrieval capabilities offer more flexibility in information retrieval. They have been used for all textual documents of the same unique CPR. Any document can be retrieved according to its contents. An arbitrary request over the CPR returns a catalog of hits, *i.e.* the set of documents that contains the requested words.

4. Discussion

The proposal of a CPR as a Medical Document Management System, demonstrated by the mock-up, raised a strong interest. The approach accounts for current clinicians' practice and does not enforce any constraining model. Similar experiments have been reported (*e.g.* [6, 8]), even using the now up-to-date WWW technics (*e.g.* [9]). The importance of CPR content syntheses has been stressed. both as summaries and as synoptic views [10].

Syntheses and presentations suited to the task, to the specialty (cf. [11]), or to the reading attitude and physician goals [4], and their connections to original data are heavily expected. Thus, the contextual production of both synthesis documents and the underlying hypertext structure becomes an issue. In this respect, natural language processing (NLP) should provide tools to automate the process. This necessitates that patient record models, but also social consideration on medical pratice, *i.e.* workflow, are taken into account (cf. [3, 2]). NLP should also enhance document indexing and consequently various retrieval strategies (based on words, terms, or even concepts).

5. Conclusion

A prototype implementation limited to 3 departments in "La Pitié-Salpêtrière" is planned. A first phase will focus on HIS connection and document input to enable the PPR replication and its consultation. A second phase will enhance the system with synoptic document and hyperlink production on a professional reader's workstation.

References

[1] K. Moidu, J. J. Falsome, and S. Nair. Computer-based patient record: The essential data set approach. In *Proceedings of the 18th Annual SCAMC*, pages 462–466, Washington, 1994. Mc Graw Hill.

[2] A. M. van Ginneken. The structure of data in medical records. In J. H. van Bemmel and A. T. McCray, editors, *Yearbook of Medical Informatics 95 - The Computer-Based Record*, pages 61–70. Schattauer, 1995.

[3] M. E. Frisse, J. L. Schnase, and E.S. Metcalfe. Models for patient records. *Acad. Med.*, 69:546–550, 1994.

[4] E. Nygren and P. Henriksson. Reading the medical record. I. Analysis of physicians' ways of reading the medical record. *Computer Methods and Programs in Biomedicine*, 39:1–12, 1992.

[5] H. J. Tange. The paper-based patient record: Is it really so bad? *Computer Methods and Programs in Biomedicine*, 48:127–131, 1995.

[6] E. Nygren, M. Johnson, and P. Henriksson. Reading the medical record. II. Design of a human-computer interface for basic reading of computerized medical records. *Computer Methods and Programs in Biomedicine*, 39:13–25, 1992.

[7] B. R. Schatz and J. B. Hardin. NCSA Mosaic and the world wide web: Global hypermedia protocols for the internet. *Science*, 265, 1994.

[8] K. Adelhard, R. Eckel, D. Hölzel, and W. Tretter. A prototype of a computerized patient record. *Computer Methods and Programs in Biomedicine*, 48:115–119, 1995.

[9] J. J. Cimino, S. A. Socratous, and P. D. Clayton. Internet as clinical information system: Application development using the world wide web. *Journal of the American Medical Informatics Association*, 2(5):273–284, 1995.

[10] S. M. Powsner and E. R. Tufte. Graphical summary of patient status. *Lancet*, 344:386–389, 1994.

[11] A. M. van Ginneken and H. Stam. Can one patient record accommodate the diversity of specialized care. In *Proceedings of the 19th Annual SCAMC*, pages 406–410, New Orleans, 1995. Journal of the American Medical Informatics Association.