PureMD: a Computerized Patient Record Software for Direct Data Entry by Physicians Using a Keyboard-free Pen-Based Portable Computer

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ABSTRACT

This paper describes the data acquisition features of the PureMD Computerized Patient Record (CPR) software designed specifically for physicians. The physician uses a stylus to point, draw and handwrite on a Dynamic Dialog Interface that provides the same flexibility as the paper record and numerous other advantages. The clinical data thus entered is highly organized, easily legible and retrievable in many ways. The underlying Medical Knowledge Base (MKB) was optimized for rapid, intuitive and consistent data entry and automatic coding with minimum handwriting.

INTRODUCTION

The need for a Computerized Patient Record is increasingly recognized by various organizations, such as the Institute of Medicine Committee on Improving the Patient Record [1]. Direct data entry by the physician is essential to obtain interactive decision support tools, but it is still a challenge. Fortunately, promising interface technologies are being developed and offer opportunities for new solutions. Some ambulatory care CPR software designed for physicians already uses the mouse and a graphical user interface for improved data entry and coding [2],[3],[4],[5]. While handwriting recognition technology was tested by nurses [6] and dentists [7] on partial CPR applications, there is no report of using this technology for the complete CPR data entry by the physician.

PureMD is a complete CPR software especially designed for physicians and dentists that uses computer handwriting recognition and graphical user interface. It is being developed by Développement Purkinje inc. with a group of physicians, dentists and computer scientists from private clinics, universities and hospitals working in close collaboration. The aim of the project is to increase physician's efficiency with innovative tools in clinical data management.

METHOD

The software is being developed by Développement Purkinje inc. using successive incremental prototype method. The research started two years ago and is being sponsored by five hundred Canadian physicians and dentists.

The software and Medical Knowledge Base and their improvement are first designed by a team of physicians and computer scientists. They are developed as new prototype and tested by physicians in clinical simulations and finally tested in a real environments.

The medical software is designed and developed by a team of twenty computer scientists, while the Medical Knowledge Base is developed by forty physicians (specialists and general practitioners) and revised by five physician-analysts trained in knowledge

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engineering. All physicians are working clinicians in a variety of practice environments.

The development cycle ends with testing. Simulations are performed by another group of forty clinicians to validate the Medical Knowledge Base and the Dynamic Dialog Interface. Field testing in private clinics started in autumn and is expected to last a year and a half. Over three hundred physicians and dentists will participate in testing successive prototypes in experimental settings. Feed-back from these tests is transmitted to development teams for further improvements.

TECHNOLOGICAL CONSIDERATIONS

The PureMD software is an event-driven object-oriented application written in C++.

A UNIX server stores the reference MKB and the patient records on optical disks (WORM). It also contains the programs that transmit the MKB and patient records to the physician's computers. The server's network uses TCP/IP transport protocol over Ethernet channels to communicate with the physician's portable and desktop computers. Its communications server can also transmit and receive data from laboratories and billing agencies.

Another program runs on MS-DOS pen-based and desktop computers. The secretaries use a conventional keyboard and mouse for data entry, while the physician writes on a portable pen-based computer. This computer uses no keyboard and requires a stylus to handwrite, draw or select from the interactive screen. Built-in handwriting recognition (HR) algorithms can translate uppercase and lowercase block printing as well as numbers into standard ASCII codes. Although HR is rather fast and accurate, the delays involved are sufficient to interfere with the physician's work, if he could only write in block letters. To obtain a better computerized record than its paper counterpart, the goal of the research is to achieve automatic coding and substantially decrease writing, thus accelerating data entry and retrieval. The PureMD system is designed to display a selection of relevant clinical items the physician might decide to record. The choices of clinical items provided by the system are related to the patient the physician is currently examining. A matrix of data is presented to the physician so he can complete his patient's chart quickly and accurately; he can make his choices only by pointing to them, which nearly eliminates handwriting. This feature is further described in the Dynamic Dialog Interface section.

MEDICAL KNOWLEDGE BASE DESIGN

The Medical Knowledge Base is structured according to the traditional patient record and contains: a patient identification section, the chief complaints and current illness descriptions, the concomitant symptoms, the personal past medical history and family medical history, the review of systems, the social profile, the physical examination, laboratory tests and procedures, lists of diagnoses, the investigations and treatments, patient information handouts and follow-up considerations, a complex medication data base, etc. All of the above are detailed in a comprehensive and consistent logic as items of the MKB. We define an *item* as the finest granularity of a recorded information. The MKB already contains over 50,000 different clinical observations.

Considerable efforts were made to develop a uniform and logical model of every section of the MKB such as symptoms, signs, etc. The chronology of the symptom is a good example of the ingenuity needed to develop a successful natural interface, because it can be difficult to display even a simple descriptive field as this one. Simple acute symptoms only need a minimum chronology, while diseases with multiple levels of chronology, as the cluster headache, require a complex syntax. Indeed, a cluster headache might have been occuring every night for two weeks, and every other semester since age 18. Multiple time periods are stated in the last description. One elegant solution could be to provide a single chronology data entry field flexible enough to generate either a complex or simple description. A recursive chronology field based on an episodic symptom concept has been designed and is currently being tested by physicians. In the same manner, many natural and intuitive solutions that seem effortless to the physician need careful design.

DATA ENTRY USING THE DYNAMIC DIALOG INTERFACE

To write medical findings, the physician first chooses the context of the visit. It can be any or *a combination* of the following statements: the chief complaint, a problem, a symptom, a syndrome, a follow-up visit, a treatment plan or a disease. The Dynamic Dialog Interface (DDI) consequently acts as a filter on the Medical Knowledge Base and displays the relevant structured observations according to the previous choice(s). The data is displayed in a scrollable window according to a problem-oriented record-like format (Subjective, Objective, Assessment, Plan). It can be acted upon in numerous ways using the stylus device. Almost 250 clinical context encounter filters have been written by physicians, revised and programmed and another 1000 are under development.

Pointing to a clinical item is the simplest way to record it. By selectively pointing to different parts of an item, the physician is recording his statement as well as getting more details. In the latter case, the DDI looks in the MKB and displays items from which the physician can choose to qualify his findings.

The physician can also add anywhere in the record handwritten notes or sketches. Using special gesture recognition capabilities of the pen-based computer, the physician adds detail to an item and records it, all in one operation. He thus specifies the *absence* of a symptom, an *equivocal* or *negative* sign or an *unsuccessful* procedure.

Specialized drawings and Graphical Metaphors (GM) are also part of the MKB and can be retrieved by the DDI in the appropriate context. They are used daily by physicians and are medical equivalents of shorthand notes. GM are a promising field of cognitive science [8] and deserve to be implemented in new CPR. The stylus interface can further enhance traditional sketches and GM: with automatic coding, they could be translated into words for external reporting. This new feature is currently under study. Examples of currently used GM are the Maigne and Lesage star drawing of the spine [9] and the visual recording of the joint examination [10].

In addition, the DDI can be customized without losing its automatic coding capacity. This gives the user the flexibility of writing his own protocols.

INTEGRATED RECORD OPERATION

There are many reasons for adopting a CPR, one of them is avoiding repetitions. Many features of the system eliminate useless repetitions. Let us take the example of medications: the physician prescribes a drug once and it is recorded in the time-oriented record, added to the current medication profile of the patient, compared with other drugs for interactions and finally printed-out with educational material to hand out to the patient. On the next visit, the refill of medications is done by pointing to them.

Data communication is another important feature. Laboratory request can be directly transmitted via a modem. Automatic coding permits direct transmission of billing to insurance companies or proper provincial government in Canada. Data transfer is done in the appropriate format. ICD-9 and DSM-3R are currently used, and the upcoming SNOMED III is under study.

ACCESS TO THE CONTENT OF THE RECORD

The clinician may look in the record in a variety of ways. The latter can be read in a traditional time-oriented format (paper metaphor) or in a problem-oriented format. Furthermore, it can be scanned according to different criteria.

The program uses lists to query the record. The main lists include problems and diagnoses, past history, allergies, past and current medications, laboratory tests. These lists are automatically updated during data entry and from the patient profile; they can be customized by the user.

Time progression of any recorded item or group of items is under study and will be queried and displayed in different manners: textual, several column table-like, time-oriented graphical, etc. The item might be as general as a symptom or a system or as precise as a positive clinical sign.

DISCUSSION

Extensive semiological refinements have been involved in the design of the MKB. The result is a better understanding of medical terminology and multiple levels of abstraction involved in the medical record. The improvement of the patient record can favorably affect the cognitive decision process of the physician. A more comprehensive record might therefore translate into a better understanding of the recording process.

The immediate benefits from using such a system are a legible record, faster data entry and improved retrieval tools, automatic coding (for clinical research and billing purposes, laboratory data transfer, etc.), the simultaneous use of decision support tools and a substantial reduction of repetitive tasks.

In conclusion, the CPR model described in this article can offer the same flexibility as its paper counterpart with major improvements.

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