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MODELING PATIENT CARE FOR MULTIMEDIA DATABASE

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ABSTRACT

In the medical arena, the number of uses for new technology is increasing rapidly. In the last few decades, physicians have been using more computerized tools and are basing their diagnoses on high-tech lab results. While the tools used for diagnoses -- such as catscans, MRI's and the myriad of other high-tech equipment -- have improved greatly over the years, the method of storing these results into a medical record has not changed much. In fact, the medical system is using antiquated methods of paper-based record, and this results in inefficiency. The record-keeping system simply does not allow for the high-tech equipment to be used to their greatest potential.

Medical professionals are confronted with a basic issue: How should they manage the huge amount of different types of information so that they can improve medical treatment and upgrade patient care? The case study presented in this paper deals with the Emory Clinic, located in Atlanta, Georgia, which treats a very high volume of patients. This paper provides a study of the patient care process, development of an initial product data model, characterizes and identifies multimedia datasets and finally presents a screen mockup that reflect some of the datasets.

NOMENCLATURE

GT - Georgia Tech
IDEF0 - a functional data model
MMDB - Multimedia Database
MRI - Magnetic Resonance Imaging
EXPRESS-G - a semantic model
SOAP - Subjective, Objective, Assessment, Plan
WIMP - Windows, Icons, Menus, and Pointers

INTRODUCTION

This work is part of an effort to construct a generic approach for multimedia database development. One of the areas in this effort is in the medical arena which has a very large information flow. Constructing medical databases can be attacked from several points of view, and each will emphasize a specific aspect in the field. Possible views would be of the following categories: insurance, treatment efficiency, legal aspects, or efficacy. The view we are examining is the diagnosis and treatment of the patient.

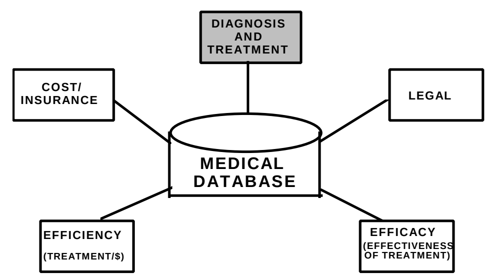

Figure. 1

A medical database would be of great use to a large clinic such as one at Emory. Despite the fact that computers have been a part of our workplace society for many years now, they have not infiltrated the medical arena as much as one might expect. In fact, the area of medical record-keeping has not changed much over the past few decades. Most of the work done in the medical arena was focused in computerizing the scheduling and registration -- stages involving clerical works.

The technical part of patient care that is related to the doctor has a great potential for advancement. Multimedia databases could greatly improve many aspects of patient care. For example, a patient goes to see a doctor for an ongoing problem with knee pain. The doctor would like to see the patient's x-rays from a year ago to see how the condition has progressed. However, the doctor simply cannot do this because under the existing system old x-rays are kept in different archives, where they are often lost. Even if the x-rays have not been lost, it may take days to retrieve them. Therefore, the physician is lacking this data at the time patient comes in for a visit and is at a disadvantage in treating the patient. Using a comprehensive multimedia database, the doctor would be able to access these old x-rays in a matter of seconds using the computer.

There are additional problems under the existing system when the doctor wish to refer the patient to another physician. In some cases, the first doctor may call the second doctor on the telephone to explain the situation, or may write a note. When that patient shows up at the second doctor's office, that doctor may not have all the needed information. In fact, the patient may have to repeat some of the exams again. If a multimedia database system were in place, the second doctor could easily pull up on the computer a video of the first doctor explaining the situation and demonstrating the patient's problems using results from x-rays, MRI's, and other tests.

BACKGROUND

This project is a triad effort between Digital Equipment Corporation , Georgia Institute of Technology; and two companies that are defining the applications requirements, BellSouth and Emory. The project team was formed to investigate the integration of data management technology with multimedia storage and hypermedia/graphical user interface capabilities. This resulted in a multimedia information broker or multimedia database (MMDB). The Georgia Tech (GT) research assistants form an interdisciplinary team of Mechanical Engineering and Computer Science students. The GT team is subdivided into three groups: applications group, database group, and user interface group. Digital is the link between GT and the application providers. Both BellSouth and Emory provided applications as case studies, which aided in the formulation of the requirements. This paper will follow the medical activities. A companion paper in these proceedings, A Prototype Multimedia Auto Broker, gives the details of the other application (Birkes et al., 1995).

OBJECTIVE

This work has several goals. The first goal is to learn and understand the diagnosis and treatment process (from the patient treatment view). The task is achieved by constructing an IDEF0 functional model. Next, an initial conceptual data model of the medical arena is presented. At this point multimedia datasets are identified. Finally, after the players and their roles are modeled and understood, a set of mockup screens is presented. The mockup screens defines some of the user interface aspects as well as some key access to the database.

TOOLS

IDEF0

The goal is to convert human knowledge into diagrams, and to create a representation that shows what actually happens in the process and how it is combined with information tracing. Information from a variety of sources on different aspects of patient health may cause contradictions. The designer must deal with this problem, and get the comprehensive picture from the process model. Entities, relationships, and attributes should be determined in order to eventually build up a database. To model the medical health care process, we used IDEF0, which is a functional modeling tool using cell modeling graphic representation. This structured and simple tool allows us to demonstrate the decomposition of the patient data trail. (Bravoco and Yadav, 1985)

The EXPRESS-G Model

The process model sheds light on the patient health care process. To understand the players and their roles in the medical arena, a data model should be implemented. We chose to use the EXPRESS data model (ISO 10303-11, 1992). EXPRESS was used for several reasons. First, EXPRESS focuses on the definition of entities, which are defined in terms of data and behavior. Secondly, EXPRESS allows comfortable description of a domain on different abstract levels. With this data model it will be possible to develop a future database schema. The EXPRESS model may incorporate behavior attributes and even relationships. Therefore, it is possible to develop from the EXPRESS model an object-oriented data model as well as a relational one.

PROCEDURE

IDEF0 Diagram Construction

Presenting the Straw Model. For efficient study, the investigating team (designer) should study the subject to be modeled and come up with a rather abstract straw model. This straw model will focus the initial discussion with the domain expert.

Building a Preliminary Diagram. The domain expert will provide information to develop a reality abstract model from the straw model. After completing the first stage, the domain expert will take the diagram to lower levels, stating the data sets for each block. The interviewer's role is to translate the information flow from the expert to the IDEF0 terminology.

Analysis of Preliminary Design. The designer examines the preliminary design constructed with the expert in the interview stage. The goal is to understand the results of the interview and identify problems such as ambiguity of terms, different professionals' perspectives on the same procedure, homonyms, synonyms, etc. An efficient tool used to understand the expert terminology is the data dictionary, which is constructed in parallel at this analysis stage. The data dictionary includes a data identifier, which maps the data sets to media types. (e.g. audio, video, text).

Validating Analysis Against Expert. In this stage, the designer presents his interpretation of the diagram and asks the expert for answers to the problems encountered in the analysis stage. The last two stages are iterating processes.

Information from a Subjective View. In the application domain, especially when there is high data volume, it is important to attack the database from a defined point of view, thus allowing the tracing of information in a consistent manner through the IDEF0 diagram. By using this element, the designer can create a readable abstract skeleton schema.

IDEF0 Structural Information. The IDEF0 diagram inherently reserves different locations for verbs and nouns. This is then used to translate nouns into entities and attributes, while verbs are mapped into relations. The encapsulation property of the

IDEF0 diagram contributes to the designing of the conceptual model in the required level of abstraction.

Building an IDEF0 diagram forces the designer to use the relevant application terminology. Composing a data dictionary enhances designer comprehension, thus detecting homonyms, synonyms, and ambiguity problems.

CASE STUDY

IDEF0 Construction

After several interviewing and validation sessions, the functional diagram was built. The domain experts were clinical staff, including information experts and medical personnel. As a starting point, the manager of the information management team provided an overall description of the process. Five main actions were identified.

Make Appointment. The patient personnel information, chief complaint and insurance data are gathered at this point. The main outcome of this stage is the appointment time and a designated physician for the patient.

Register and Check-In. The main role of this stage is prepare the patient's case for the physician.

Examine Patient. This is the first stage where the physician looks at the patient and his medical record. The typical output of this stage is an initial symptom assessment, a set of initial exams, and lab tests to be executed.

Assess Eesults and Determine Plan. The physician uses the lab results, subjective information from the patient, and his own knowledge to come up with a diagnosis and a plan.

Treat Patient. This is the fifth and sometimes the last stage that the patient passes through . In this stage, the physician assigns a treatment and a plan for further care to the patient. As illustrated in Fig. 2, the treatment stage is not necessarily the final stage. Output from the fifth stage may be used for a reassessment and a new plan for further treatment.

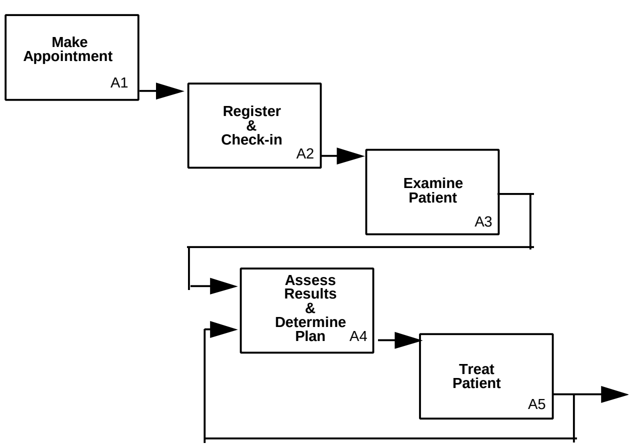

Figure 2

The paper concentrates on the physician's activities in this model; therefore, we developed the above stages. The register and check-in stage is composed of three main parts. First, in the registration stage, the patient registers and the insurance documents are verified. Next, the patient proceeds to the physician's office for the check-in. The first time the patient receives medical care is in the next stage, the fulfillment of the doctor's protocol. The doctors protocol is a set of exams that a physician pre-assigns to a patient according to the reported condition. This pre-exam is performed by the nurse prior to seeing the physician. This information should be available to the physician upon the initial meeting with the patient. Figure 3 describes schematically the "register and check-in" procedure.

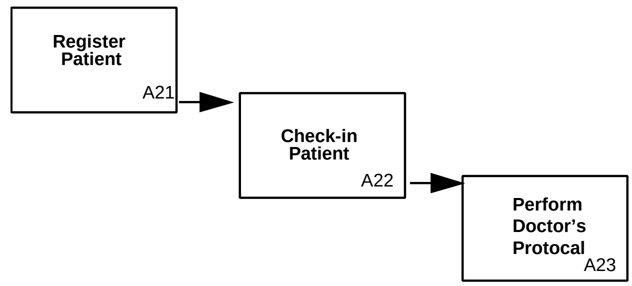

Figure 3

In the "examine patient" stage, the physician conducts the tests and orders lab results. This section is illustrated in Figure 4.

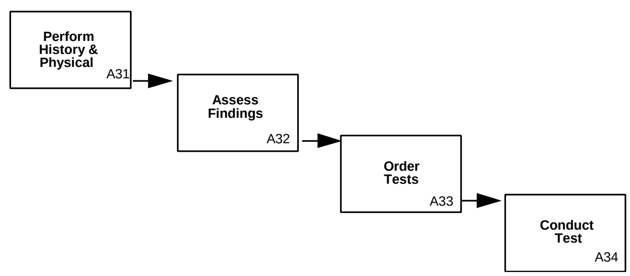

Figure 4

The physician next assesses the test results and determines the treatment plan. Finally, during this stage, the treatment and the plan are documented. A schematic description of this stage is illustrated in Figure 5.

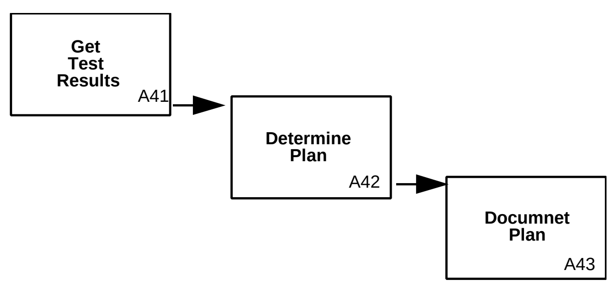

Figure 5

The data dictionary is developed in parallel with the IDEF0 construction. Special attention is given to the media type of each element in the data dictionary. A sample key dataset from the data dictionary is provided in Table 1.

Dataset	**Description**	**Type**
Discharge Summary	Information which contains a short description of patient's stay, prescriptions, and recommendations made	Text
Medical Record	Contains textual and graphical information from patient's exams. Also included is the medical history like allergies, family history, immunizations, etc.	Text Graphic Video Audio
SOAP	The Subjective, Objective, Assessment, and Plan notes dictated into a recorder or handwritten by the physician	Text Audio
Vital Signs	Blood pressure, pulse, weight, height, and temperature	Text

Table 1

EXPRESS-G Schema Building

This data model focal point is the patient. The express model allows different abstraction levels. On the main level, the important objects are patient, clinic, clinic personnel, medical record, and the insurance. On Figure 6 there is a schematic description of these entities and the relationships among them.

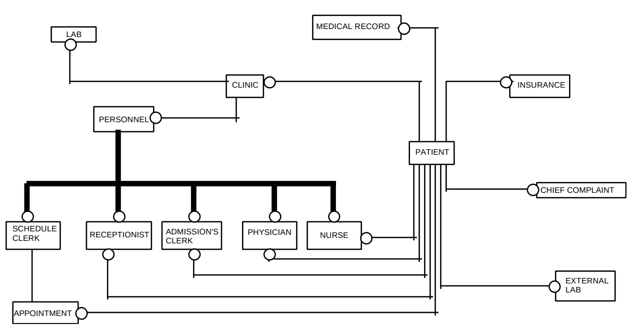

Figure 6

Multimedia Datasets

Most of the datasets used in this process are text oriented. However, with the move towards computerized systems, patient care has witnessed a transition from paper trail to digital files. Especially common is the use of computerized systems for the scheduling and registration stages, although these stages are not multimedia intensive.

The multimedia dataset usage increases later during the treatment stages. The patient's medical records include lab results that are often images, graphs or sketches. X-rays and video tapes from medical exams are usually not included in the medical records. Usually the physician summarizes the test results and appends them to the medical record. In Figure 7, a partial view of the medical record and the multimedia datasets are shown. Figure 7a illustrates the relation between the lab results and the way they are incorporated to the medical record. Figure 7b illustrates a standard colonic biopsy sheet, which the physician annotates on top of the sketch. Figure 7c demonstrates a graphical computer processed graph, with the cross representing the patient exam reading, and the shaded areas representing the permissible readings for a given population. The graph enables the medical team to compare patient results with the normal population.

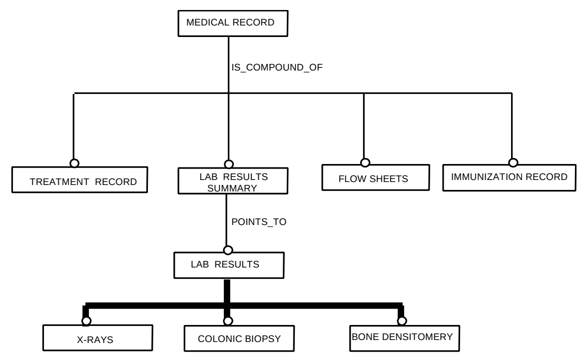

Figure 7a

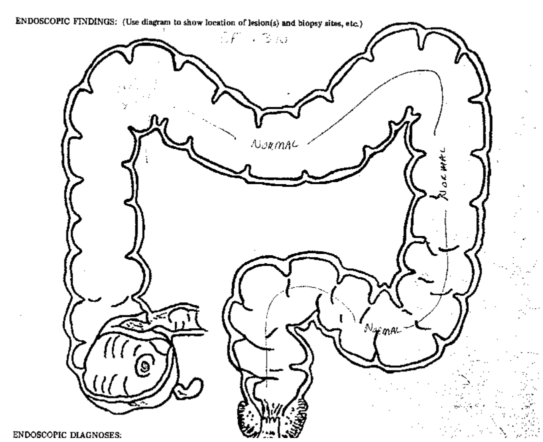

Figure 7b

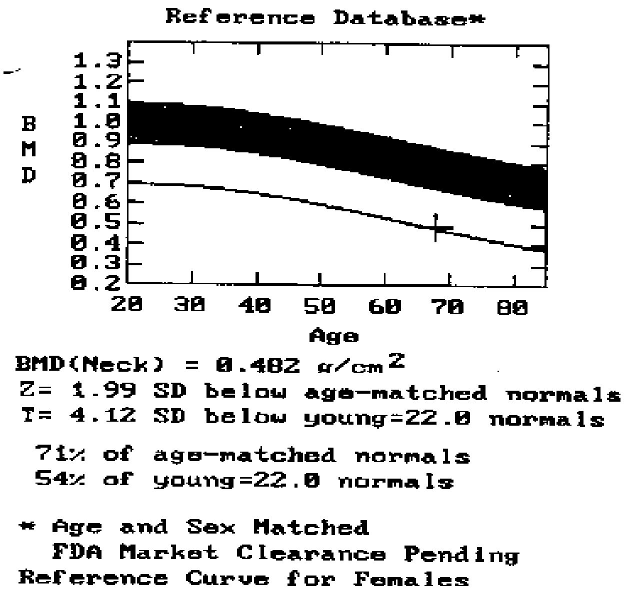

Figure 7c

USER INTERFACE MOCKUP

A truly comprehensive multimedia database system can increase the quality and efficiency of the patient care. We developed a set of initial screens (Figs. 8a-8c). These user interface screens are designed using a direct-manipulation interface called WIMP, which means Windows, Icons, Menus, and Pointer. This type of user interface is commonly seen in X-Windows, Macintosh Finder, and Microsoft Window environment. The screens were presented and evaluated by clinical personnel. The mockups are by no means a comprehensive medical information system. The screens demonstrate a sample variety of multimedia datasets and their probable roles in a desired system. X-rays are not an integral part of a patient medical record in the clinic system, and a brief x-ray exam summary is usually attached to the medical record. A future system that incorporates the x-ray image and other multimedia lab results within the medical record will: (1) prevent degrading the lab results to a textual form for the short run and (2) will allow tracing and historical follow-ups for the long run. In addition, the use of the physicians' and the patients' photographs may improve communications.

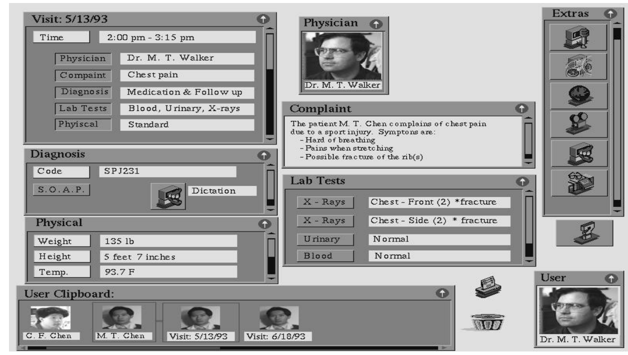

Figure 8a

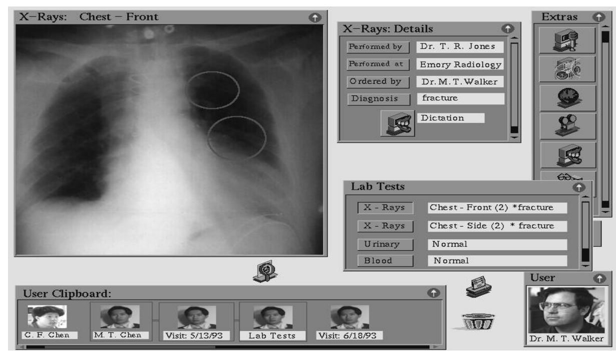

Figure 8b

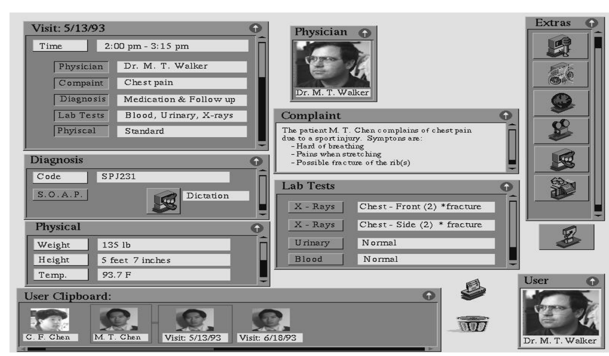

Figure 8c

CONCLUDING REMARKS

This paper investigated the patient care process. A comprehensive process model was suggested for a clinic's generic patient care procedure. An initial EXPRESS data model was developed and mockup screens were presented. Currently, multimedia datasets are not incorporated into the patient medical record to form a coherent multimedia information system. Modeling this clinic's process was the first step towards prototyping database capabilities.

Use of the multimedia data would provide many improvements to the current system of medical record-keeping. Several key issues were exposed: First the multimedia information for the medical system experiences a media transformation. For example, a picture like the colonic biopsy in Figure 7b does not appear in the medical record. Instead, a textual summary of the findings is included within the medical record. A physician dictation is then transcribed into a textual form. Incorporating the original media format into the medical record is desired in order to reduce information loss. Next, the multimedia data is distributed all over the medical spectrum. X-rays, catscans, MRI records, and other multimedia datasets are sometimes lost or simply destroyed. Finally, multimedia datasets is more than a basic classification to a media form. The enhancement in media form from textual information to pictorial information allows complex datasets as annotations on a picture (Figure 7b). The use of the physicians' and the patients' photographs may improve communications.

This work identified problematic issues involved in a complex, data-intensive and media-rich medical field, and an overall foundation for a comprehensive multimedia database and user-interface were laid. This effort is only an initial attempt at identifying the problems in organizing the medical record. The use of multimedia technology will greatly improve the patient's treatment through better communication in the medical record.

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