MEDINFO 98
B. Cesnik et al. (Eds)
Amsterdam: IOS Press

A Multimedia Database for Dermatology

Hauke Kindler[a], Dirk Densow[b], Alexander E. Baranov[c], Theodor M. Fliedner[b], Ralf U. Peter[d]

[a]*Research Institute for Applied Knowledge Processing at the University of Ulm, Germany*
[b]*World Health Organisation Radiation Emergency Medical Preparedness Centre at the University of Ulm, Germany*
[c]*World Health Organisation Radiation Emergency Medical Preparedness Centre, Hospital No. 6, Moscow, Russia*
[d]*Department of Dermatology of the University of Ulm at the Federal Armed Forces Hospital Ulm, Germany*

Abstract

The World Health Organisation (WHO) Radiation Emergency Medical Preparedness (REMPAN) centres have built up the International Computer Database for Radiation Accident Case Histories (ICDREC) to document the treatment of acute radiation syndrome (ARS) patients.

Radiation induced skin lesions may cause severe late effects in radiation accident patients. Dermatological multimedia documentation is included into the ICDREC. In particular, retrieval and display of digitised skin photographs and medical reports serves to improve patient care, medical education, and scientific analysis concerning the cutaneous radiation syndrome (CRS).

The database has been built up as a client/server system. A particular focus has been set on using commercial off-the-shelf software components. The medical data including the multimedia data are stored in a relational database system. The database can be accessed by inexpensive personal computers in the dermatologist's workplace. Authorised institutions can access the database via the Internet. Retrieval of one skin photograph via local area network (LAN) requires approximately 3 seconds.

The current state of the application is illustrated with the skin lesion treatment of a Chernobyl patient. An example is given on how to access the ICDREC from a dermatologist's desktop personal computer.

The discussion focuses on the advantages of storing the textual and pictorial data in one central database to be accessed from different care centres and how the results can be generalised for medical multimedia information systems.

Keywords
Information Storage and Retrieval, Dermatology, Multimedia, User Computer Interface, Internet, Conceptual Data Model

Introduction

The WHO REMPAN centres Ulm and Moscow have built up the ICDREC [1] to document ARS case histories. Formerly the ICDREC has been known as the Moscow-Ulm Radiation Accident Clinical History Data Base (MURAD) [2]. The computerised management of ARS patient records was initiated by virtue of the Chernobyl reactor accident.

Ionising radiation affects all organ systems, especially proliferating tissues, e. g., the haemopoietic system and the skin. One design objective was the development of a data model and database implementation capable of providing the flexibility needed to support a broad spectrum of medical specialities. The database serves to document the radiation effects for a patient's life span.

High dose radiation exposure damaged the patients' skin during the Chernobyl reactor accident [3]. Later-on skin ulcers, necrosis, and atrophy appeared diminishing the patients' well-being. Dermatological treatment of the most severely affected patients has been performed in several centres of excellence in Russia, Ukraine, and Germany.

35 mm slides are a well established documentation means in dermatology. The photographs serve to decrease the clerical documentation effort. Primarily they are used to document the development of the skin lesions which is a prerequisite for monitoring a patient's treatment as well as to facilitate follow-up and to determine therapeutic efficacy. Education and research in dermatology require image material, too.

Some disadvantages, however, are encountered with conventional photoarchives. Loss of slides may occur. In general the slides are ordered by date causing extra workload to prepare slides according to a patient's medical problem. Slides must be stored at or transported to the place where the progress reports are generated. Multi-user access to photos is difficult, e. g., the same slide is needed for a conference and patient treatment. Scientific evaluations are only possible by time-consuming sequentially scanning of photos.

These disadvantages can be overcome by providing digitised slides in a multimedia database. Fast retrieval of slides using indices is possible. Several centres involved in a patient's care process can access the database. Time is saved in patient care and scientific evaluation. The constant improvement in computer power and performance nowadays offers convenient and efficient means of presenting multimedia information. With this improvement the trend towards integration of multimodal clinical documents from patient records is a logical consequence.

In the following we describe the multimedia aspects of the ICDREC concerning dermatology.

Materials and Methods

Materials

The core of the multimedia database for dermatology comprises 15 case histories of patients with severe skin lesions involved in the Chernobyl reactor accident. The patients have suffered from a wide variety of health complaints, e. g., atrophy, ulcers, necrosis, fibrosis.

Shortly after the accident Polaroid® pictures have been taken by the physicians in Russia. Medical photographers have taken 35 mm slides to document the treatment performed in Germany. Additional clinical findings, laboratory results, examinations, and diagnoses have been documented in textual form. For scientific purposes the material has been complemented with pictures from Brazil and China. At the moment 476 photos present the content of the database.

Methods

Advances in relational database, user interface, and image digitising technology have enabled the development of multimedia databases with commercial off-the-shelf products.

The dermatological multimedia database is realised in client/server architecture separating the user interface from the database management system. A graphical user interface provides access to the multimedia data through networked-based client/server computing. User interface and database communicate through several protocol layers, i. e., Open Database Connectivity (ODBC), SQL*NET®, and the Transmission Control Protocol/Internet Protocol (TCP/IP). The physical layer consists of Ethernet networks with a Fiber Distribution Data Interface (FDDI) backbone. Though using off-the-shelf products a considerable tuning effort has been necessary. To obtain optimal bandwidth usage for image transfer the SQL*NET® buffer size had to be adjusted to 1024 bits. Therewith one buffer fits into a maximum length physical packet whose size is limited to 1500 bits by the Ethernet specification [4].

An ORACLE7™ database on a UNIX® server houses digitised still-images and textual data including the dermatological examinations. They are modelled by a general conceptual data model. It is depicted in figure 1 according to the entity relationship (ER) approach [5]. The examinations are identified by patient identifier, date of admission plus examination time, type, location, and organ. Entity identifiers in figure 1 are underlined. In dermatology the organ is skin and the examination type is inspection. One examination may possess several results, one report, and several binary large objects (BLOBs). A dermatological examination may be documented with several photographs taken with different exposure times and magnifications or from different angles eventually supplemented by ultrasound images and other innovative resulting, e. g., skin profilometry, histological examinations. This general approach to store examination results including multimedia objects avoids having one table for each type of examination [6]. The keywords from the report are put into result to index examination. They are selected out of a standardised vocabulary. The location is coded according to a hierarchical schema [7], e. g., the left arm is coded as 4L (4 for arm, and L for left). The physical design has been directly derived from the conceptual model.

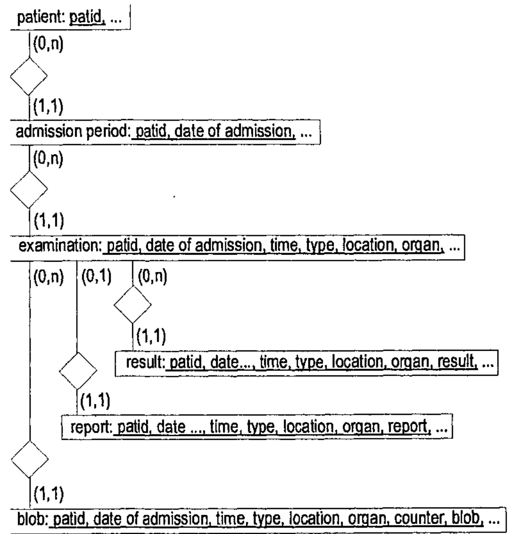

Figure 1 - ER diagram for examination documentation.

Image input is done on a personal computer with Windows™ 3.11 as operating system (PC) equipped with a Hewlett Packard ScanJet 4c® plus transparency adapter and Adobe Photoshop®. Satisfactory quality is obtained scanning paper prints and diapositives mounted in glass with highest resolution and colour depth. The images are noise filtered and archived as Joint Photographic Expert Group (JPEG) files on tape for future use and as 256 colours Windows™ Bitmap (BMP) files to be used in the multimedia database for dermatology. A BMP image has a size of 300-500 Kbytes and measures 790x540 points. PCs with 1024x768 dot colour display and 8 bit colour video card are used as client hardware. The BMP images displayed with Microsoft Paintbrush® using an individual colour palette provided the best subjective impression for the given hardware. Object Linking and Embedding (OLE) is employed to launch the viewer to present multimedia data. The time needed for display is low compared to other image formats.

The second task in the workflow is the indexing of the images and the generation of the progress report by the dermatologist. For these purposes the dermatology case reports can be accessed on any workstation with a customised user interface written in Microsoft Access®, see figure 2. Retrieval of images is possible by patient number, location, and result in the upper left of the user interface. The patient identifier *1049* is chosen from a drop down list. The location *4L** indicates that all locations which begin with *4L*, i. e., all parts of the left arm, shall be taken into account. The result field allows to search for certain results, * allows any result. In case only photos with fibrosis are of interest *fibrosis* should be selected from the drop down list.

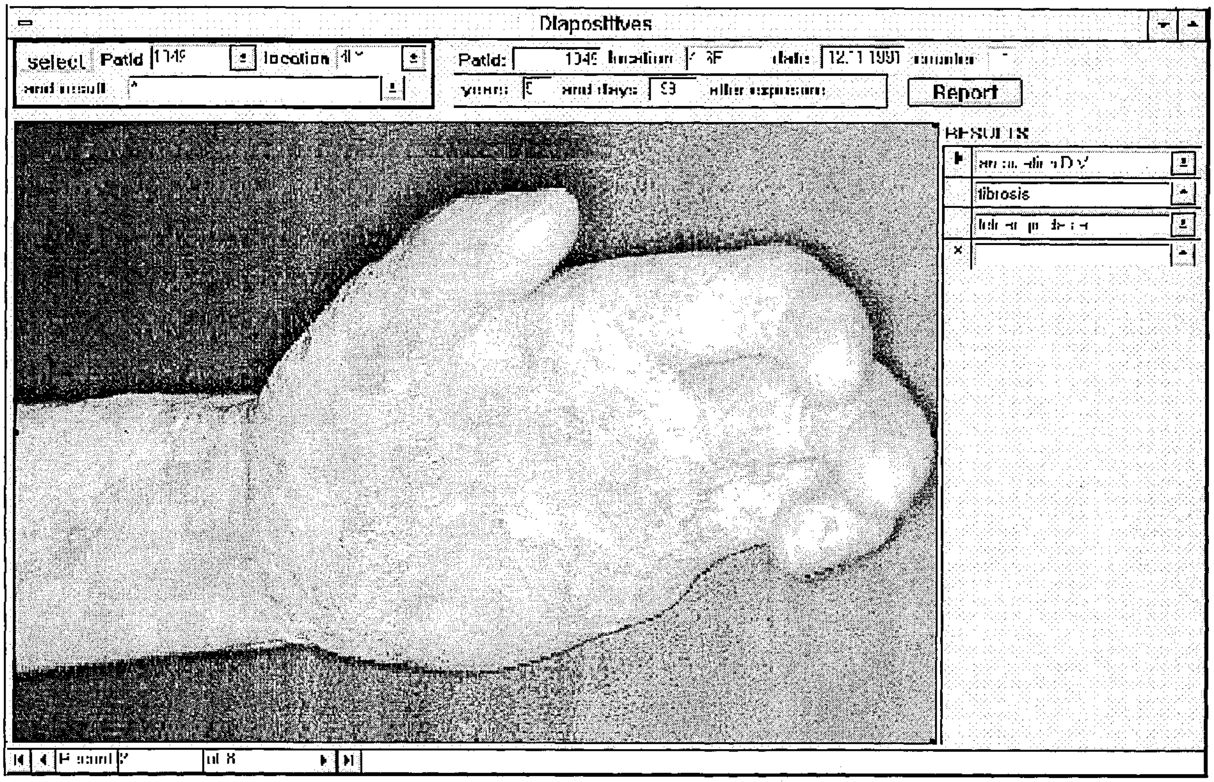

Figure 1 - Scanning the pictures and inserting clerical data, e. g., patient identifier, examination time, is done by technicians. This first task in the workflow is performed using a form/subform user interface written in Microsoft Access®.*Patient 1049's left hand after amputation of the fifth finger due to radiation vasculopathy.*

The content of the drop down list of one of the three fields depends on the content of the two other fields, e. g., if *4L** and * is chosen in figure 2 only patients who have left arm skin lesions will be choosable in the patient identifier field. Retrieval of the slides matching the criteria is done with a structured query language (SQL) statement generated out of the user's input. The images matching the criteria are presented in chronological order.

In case the progress report for an examination has not been completed, the dermatologist marks the results using the drop down boxes on the right. The report can either be dictated or typed in after clicking the report button. Generating the progress note the dermatologist may browse through the chronologically ordered slides. Dermatological research is supported by the same user interface.

Results

Hitherto, 476 images of 21 patients have been stored in the database. Image data volume is 153 Mbytes. The textual data of 521 patients have a volume of 120 Mbytes.

In the following the course of the radiation skin lesions of patient 1049's left hand is described. Photos of the lesions are depicted in figure 2.

At the time of the reactor accident patient 1049 was located about 20 m from the reactor hall. After the explosion his body surface was covered with hot water and black dust which he washed off after one hour. Patient 1049 was initially treated at the Hospital No. 6 in Moscow. The CRS of the left hand (4L6) developed slowly which is typical for radiation burns. A prodromal erythema on the palm of the left hand (4L6F) was first detected on day 2. Erosions occurred on day 17 and epithelisation of the erosions on day 20. The necrotic tissue of 4L6F was removed on day 54 and an autotransplantation of a free skin fragment was performed. After 8 months the fifths finger had to be amputated.

In the following the patient was treated several times in Germany with physical therapy to improve the mobility of the fingers, linola oilbaths, and ointments. Figure 2 shows 4L6F in year 5 with fibrosis and missing fifth finger. Altogether 8 pictures complement the medical documention of the treatment of the left hand performed in Russia and Germany.

The use of the graphical interactive interface facilitates interaction with the multimedia database, which allows access to users with limited computer experience. The training effort for the user interface is small.

The time to display an image via an Ethernet link is 3 seconds during normal working hours, which the users felt to be acceptable. The transfer time heavily depends on the bandwidth of the underlying physical network. Due to the usage of the TCP/IP protocol database access is also available through the Internet. Applying a 28 kbauds modem the time to transfer a photo is 30 seconds.

We are on the way to extend the database by other multimedia information, e. g., photos of the accident scenario, ultrasound images, X-rays, and bone marrow smears. However, the value especially of the latter is limited due to the visualisation quality of the client hardware.

Discussion

Yoshihara [8] developed tinyPACS to allow hospital-wide access to radiology images avoiding an expensive picture archiving system (PACS) solution. Ethernet has been applied as physical layer, Ethertalk as protocol, Macintosh® computers as clients and servers, a high resolution video camera for image input, and the Macintosh® PICT format with JPEG compression and a file system for image storage. Despite the fact of using smaller images (512x512x8) the response time to fetch a picture is longer. This is due to the JPEG decompression on the client. Nevertheless, 3.8 seconds have been considered as satisfactory by the end users. Using a file system instead of a database is disadvantageous concerning update, delete, insert, and retrieval operations in a multi-user environment.

Takeda [9] delivers 2kx2kx12 X-ray images to an out-patient department with a PC-based PACS. FDDI and Ethernet form the physical layer. JPEG compression reduces the image size by 84%. The transfer time is 15-30 seconds applying a JPEG board for decompression which seems to be acceptable. The throughput of the out-patient department is increased by the faster delivery of the X-ray images.

McNeill [10] provides network access to chest X-rays for an intensive care unit to speed up diagnostic decision making. The 1024x1024x8 images are delivered on a FDDI layer with transfer times below 3 seconds which seems to be satisfactory. The system saves 30-45 minutes time per day per physician. The physician's interface is reported to require no training.

Lowe [11] is developing an object-oriented multimedia database to offer image data in a clinical information system. At the moment Macintosh® PICT, Ethernet, and Ethertalk are applied. It is intended to switch to TCP/IP and FDDI. The images are indexed using the Unified Medical Language System (UMLS).

Pinciroli [12] has developed a prototype of a multimedia medical record for angiocardiographic data based on an object-oriented database management system (OODBMS). However, currently available OODBMS still need improvements both in the schema update and in the query facilities.

Dermatological images in form of a teaching book are made available on the World Wide Web (WWW) by the University of Erlangen. They are coded with JPEG in low rendition. The images are classified by disease and not indexed by different criteria. Navigation is facilitated by the use of thumbnails.

RDBMSs capable to store BLOBs provide high transaction rates and reliability. Their extension to object-relational database management systems will provide some interesting features. Methods for automatic indexing, image understanding, and delivery of images with different compression rates according to the underlying physical network could be realised. The delivery of low quality X-rays and photographs is possible on Ethernet with FDDI backbone and affordable client hardware. Better physical layers and better client hardware is necessary for the distribution of high quality X-rays and haematological slides.

Proprietary image formats like Macintosh® PICT and Windows™ BMP seem to give the best results with affordable hardware. Nevertheless standards like DICOM [13] and DICOM for visible light will shape the future. Indexing of images by body area, examination date, and type improves the search for relevant images [14]. A standardised vocabulary is a must, utilising UMLS or the DICOM vocabulary would be even better.

Image input will become more efficient using modalities with digital output. Digital cameras are still developing to deliver images in sufficient quality. Nevertheless scanning will still be necessary to include old photographic material. Film scanners are more suitable for processing diapositives than scanners with transparency adapter.

Conclusion

The amount of nontextual data generated in clinical medicine has dramatically increased. Systems for the classification, retrieval, and integration of clinical images are developed. Recent advances in database technology, imaging, and networking technology now make it technologically and economically feasible to provide many types of pictorial information throughout a hospital to improve patient care decisions and reduce costs.

The before described database delivers dermatological multimedia data via TCP/IP to inexpensive personal computers in the workplace used for patient care, education, and research. It has been realised with off-the-shelf components in client/server technique. It is used for a multi-center follow-up of a long-durating disease in Kiev, Moscow, and Ulm, which is enabled by Internet accessibility. These preliminary results indicate that there will be great challenges and opportunities for improving care and teaching in the future. The database is operational, but, lessons about its usage in hospital routine still have to be learned.

The experience is valid for dermatological treatment after radiation effects and it can be assumed that the database will be generally applicable for dermatology. The general conceptual schema will be extensible for most kinds of multimedia data. Only the physical layer, the client hardware, the image format, and the vocabulary will have to be replaced.

Acknowledgements

The presented work was partially funded by the Bavarian Red Cross, the European Commission, the German Federal Ministry of Health, the German Federal Ministry of Environment, Nature Protection, and Reactor Safety, and the German Federal Ministry of Defense. A. Engelke and A. Kirschner were very supportive in data processing.

References

[1] Densow D, Kindler H, A.E. Baranov AE, Tibken B, Hofer EP, and Fliedner TM. Criteria for the selection of radiation accident victims for stem cell transplantation. *Stem Cells* 1997: in press.

[2] Fliedner TM, Kindler H, Densow D, Baranov AE, Guskova A, and Szepesi T. The Moscow-Ulm radiation accident clinical history data base. In: MacVittie TJ, Weiss JF, and Browne D, eds. *Advances in the treatment of radiation injuries*. Oxford: Pergamon, 1996: 271-9.

[3] Peter RU, Braun-Falco O, Birioukov A, Hacker N, Kerscher M, Peterseim U, Ruzicka T, Konz B, and Plewig G. Chronic cutaneous damage after accidental exposure to ionizing radiation: the Chernobyl experience. *J Am Acad Dermatol* 1994: 30 piii: 719-23.

[4] Comer DE. *Internetworking with TCP/IP. Volume 1; Principles, Protocols, and Architecture*. Englewood Cliffs: 2nd ed. Prentice-Hall, 1991.

[5] Chen PP. The Entity-Relationship Model: Toward a univied view of data. *ACM Transactions on Database Systems* 1976: 1 piii: 9-37.

[6] Friedman C, Hripcsak G, Johnson SB, Cimino JJ, and Clayton PD. A generalized relational schema for an integrated clinical patient database. *Proc Annu Symp Comput Appl Med Care* 1990: piii: 335-9.

[7] Baranov AE, Densow D, Fliedner TM, and Kindler H. *Clinicalprecomputerproformafortheinternationalcomputer database for radiation exposure case histories*. Heidelberg: Springer, 1994.

[8] Yoshihara H. Development of tinyPACS: A distributed image database system under Apple Macintosh network. *Medinfo* 1995: 8 piii: 434-8.

[9] Takeda H, Matsumura Y, Kondo H, Inoue M, Kondo H, Taked I, and Miyabe S. System design and implementation of HIS, RIS, and PC-based PACS at the Osaka University Hospital. *Medinfo* 1995: 8 piii: 430-3.

[10] McNeill KM, Maloney K, Parra MV, and Alsfadi Y. Digital distribution of chest radiographs to intensive care units. *Medinfo* 1995: 8 piii: 426-9.

[11] Lowe HJ, Buchanan BG, Cooper GF, and Vries JK. Building a medical multimedia database system to integrate clinical information: an application of high-performance computing and communications technology. *Bull Med Libr Assoc* 1995: 83 piii: 57-64.

[12] Pinciroli-F, Combi-C, and Pozzi-G. ARCADIA: a system for the integration of angiocardiographic data and images by an object-oriented DBMS. *Comput Biomed Res* 1995: 28 piii: 5-23.

[13] Bidgood WD Jr, and Horii SC. Introduction to the ACR-NEMA DICOM standard. *Radiographics* 1992: 12 piii: 345-55.

[14] Roger E, Goldberg M, Dillon RF. Image organization and navigation strategies for a radiological work station. *J -Digit -Imaging* 1989: 2 piii: 229-44.

Address for Correspondence

Dr.-Ing. Hauke Kindler
FAW
Postfach 2060
D-89010 Ulm
kindler@faw.uni-ulm.de