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An International Dermatological Image Atlas on the WWW: Practical Use for Undergraduate and Continuing Medical Education, Patient Education and Epidemiological Research

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Abstract

We describe the development of an image database DOIA (Dermatological OnlIne Atlas) and present several spin-off projects using images of the atlas, e.g. student education using the atlas including results of an questionnaire evaluating computer-literacy, prerequisites and interests of students for using computers and the World-Wide-Web (WWW), a patient information system and an experiment to collect epidemiological data from patients with dermatological diseases via WWW.

The database, available on the WWW at http://www.derma.med.uni-erlangen.de, contains about 3,000 clinical images covering more than 540 dermatological diagnoses. It is designed for worldwide use; international submissions are encouraged.

One aim of the project is to compile an international reference for dermatological images, containing images of high educational quality and also covering conditions on different skin types and rare diagnoses which are not commonly illustrated in ordinary textbooks. All images were originally mapped to the Erlanger Diagnosis Code, which is a proprietary modified ICD-9 key, later also to the UMLS (Unified Medical Language System). In addition, images are described with keys for the location, physical attributes of the location and clinical and histopathological features of the lesion.

In order to facilitate the integration of the atlas into other web-based medical resources and to allow easy access to additional information, the Erlanger Diagnosis Code was mapped to the CUIs (unique concept identifiers) of the UMLS Metathesaurus. One purpose of the UMLS is to allow conversion of terms from one controlled medical vocabulary to another, thus, mapping of our diagnosis code to the UMLS CUIs allows simultaneous search for a given diagnosis in a number of other databases and also access to our image database from other databases. Mapping was successful for 619 out of 1383 dermatological diagnosis terms. For images with these diagnoses we are able to provide a hyperlink to other databases available on the Internet, such as MEDLINE, PDQ and OMIM, with automatic retrieval using the preferred vocabulary of the respective database.

By grouping all diagnoses into sets with similar morphologies we further integrated a differential diagnosis mode.

In order to educate patients via the Internet, a separate patient information system has been developed, using images of the electronic atlas. As an experiment to explore the feasibility of the Internet to gather epidemiological data from patients, users are asked to complete an electronic questionnaire covering signs for atopy.

We conclude that an online image atlas has multiple educational, clinical and research applications.

Keywords

Image-, Factual- and Research Databases; Internet; Dermatology; Skin-Diseases; Hypermedia; Medical Informatics; Telemedicine; Digital Photography; Medical Education; Patient Education; Atopic Dermatitis; Public Health; Epidemiology; Questionnaire; Survey; Computer literacy; UMLS

Introduction

Visual examination and cutaneous biopsies are two major tools in dermatological diagnosis. Thus, like few other specialties (e.g. radiology) dermatology is a highly image-oriented discipline.

The digital revolution opens new ways in storing, retrieving and distributing images. The informativeness of digital images of dermatological conditions as compared to conventional photographs [13] and slides [17] has proven to be statistically similar and in many cases digital images may even substitute for dermatologic physical examination [10]. Current developments in high-speed, high-capacity international networks and the growing popularity of the World-Wide-Web are converging in ways that have great potential for enhancing access to biomedical information.

This paper describes an electronic image database DOIA (Dermatological OnlIne Atlas) on the World Wide Web.

Offering an atlas with thousands of clinical and histological images for worldwide access has a wide range of educational, clinical, and research applications, some of which are presented in this paper.

Medical student education and continuing medical education (CME)

Due to space limitations and the high costs of printing colored images, traditional textbooks are very limited both in the scope of diagnoses illustrated ("breadth") as well as regarding the variety of images presented per diagnosis ("depth"). As any given disease may look very different in different stages and/or on different skin types, the variability of any disease is immense. Medical students and doctors in training have to see many patients in order to get the "full picture" on the various possible phenotypes of a given disease. This learning process may be greatly accelerated when students have access to a comprehensive image collection. One way to facilitate access to a high number of images is to collect them from a variety of sources, to store them in computers and to make them accessible via the WWW.

Patient education

Information is a critical factor for prevention of diseases. As in any other medical specialists, dermatologists often see diseases which are the result of the patients' lifestyle (e.g. sun-exposure increasing the risk for malignant melanoma; to be influenced by "primary prevention"). In addition, many diseases may be successfully treated when detected early (again in the case of malignant melanoma; to be influenced by "secondary prevention") or the deterioration of a given disease may be prevented by certain measures (e.g. avoidance of triggering factors in the case of atopic eczema: "tertiary prevention").

Information technology can and should be used to provide more health-related information to consumers, "the largest untapped resource for health care." [16]. Information services may allow consumers to understand, choose, and evaluate health services in new ways, and could have a positive impact on health care costs and quality [7, 16].

The Internet is a growing source of information for the public and in many respects an ideal medium to transport ideas and concepts of medical prevention to laypersons. Among health professionals the role of the Internet for prevention through providing information is still a widely neglected issue, as can be seen by the comparatively low number of non-commercial websites specialized on providing information for patients initiated by medical professionals. In order to explore the contents, the feasibility and the impact of patient education via the Internet, we gathered and analyzed patient emails requesting medical information from our staff [4], investigated the patient-doctor interaction by email [6] and proposed some measures for quality evaluation on the Internet [3, 5]. Further, we compiled a comprehensive information system for patients with atopic eczema, partly using the images from our atlas.

Clinical applications

A comprehensive image atlas may aid in diagnosing skin conditions and helps in considering differential diagnoses. As our atlas contains skin conditions on different skin types (black, white, Asian) and also rare diseases, the atlas may not only be a tool for general practitioners and non-specialists, but also for specialists encountering patients with a uncommon skin type or rare disease.

Research

International collaboration is essential to todays science and to health care. An image atlas may help to define, to classify and to grade dermatological diagnoses on an internationally consistent basis, which in turn is an important prerequisite for reliable and internationally comparable clinical and epidemiological studies. For example, researchers need "standard reference images" for severity scoring of dermatological conditions such as atopic eczema.

Another possible virtue of the online image atlas is to use the Internet as a survey tool and a tool for gathering medical information from patients. Making use of the high popularity of our patient information system about atopic eczema, we started to evaluate the Internet as a tool for obtaining epidemiological data from patients. Images from the atlas and the patient education system are used to draw a high number of patients with atopic eczema to our website, and medical data from these patients are collected using HTML-questionnaires.

Materials and Methods

Software and Hardware

The relational image database was developed under Access (Microsoft, Redmont).

The WWW-Server is a Pentium-166 with 64 MB RAM and a 2 GB HDD running under Windows NT 4.0 (Microsoft, Redmont) with the Internet Information Server 3.0 (Microsoft, Redmont) and Active Server Pages (Microsoft, Redmont). For performance-reasons HTML-pages with images are pre-created from the image database using scripts programmed with Delphi 2.0 (Borland, Scotts Valley, CA) rather than being generated dynamically ("on-the-fly") from database queries. In addition, users may perform complex queries with boolean operators, such as "show all images with erythema on dark skin".

Images

Dermatological images for inclusion into the atlas are mostly selected from our hospital archive containing 40000+ slides and hard copies. In addition, they comprise of international submissions. Currently the majority of images are clinical images, while only for a few diagnoses histological images are available.

Slides and hard copies from our own archive have first been digitized and stored on Kodak photo compact disks. For inclusion into the database images are compressed using lossy JPEG-compression.

Database structure

A relational database was developed, containing the filenames of the images as well as additional information, such as diagnosis and description keys, information about the patient, physician etc. In addition we included a database table to gather diagnosis-related URLs (uniform resource locators). This enables us to include links to other resources on the WWW interesting for a given disease on our diagnosis pages.

Database keys

Due to the lack of an existing thesaurus for describing dermatological images, several proprietary database keys were developed to describe and classify the images:

- a **diagnosis key**: We originally used the so-called "Erlanger Diagnosis Code" (a numerical code with 6 digits, based on ICD-9) to encode diagnoses. We later mapped this key to the UMLS-CUIs as far as possible (see below). Our diagnosis thesaurus contains at present 4639 terms for 1383 dermatological diagnosis. For each diagnosis at least one German and one English term exists as preferred term.
- a **diagnosis-related additional key**, internally called G-key. This key contains mainly terms which define the grading, staging, type or variant of a disease or other terms which may alter the clinical picture of a disease; thus it contains terms like "under treatment" or "after surgery" or "type 1" or "incipiens" etc.
- a key describing the **skin type** (race), called F-key
- a set of **keys for describing the lesion(s)**: we have further developed a hierarchical key to describe the lesions and localization of the lesions seen on the image with dermatological terminology. The key consists of the following sub-keys:
  - **Lesion**: C-key, e.g. "macula", "erythema", "papule"
  - **Localization**: Described by the A-key (consists of body parts, e.g. "leg") in conjunction with the B-key (consisting of additional keywords to be used together with the body part, e.g. "flexural side")
  - **Color**: D.0 - key
  - **Size**: D.1 - key (e.g. "5- 10 mm")
  - **Demarcation**: D.2 - key (e.g. "sharply defined", "irregular borders")
  - **Property of the lesion**: D.3 - key (e.g. "verrucous")
  - **Distribution of the lesion**: D.4 - key (e.g. "disseminated")
  - **Form of the lesion**: D.5 - key (e.g. "oval")

Any image is described with at least one keyword from the diagnosis key and at least one keyword from the A-key and the C-key. Keywords from the other keys (other than C-key) must be related to (must be associated with) a keyword from the C-key.

In order to enable linkage of our image database to other factual and bibliographic databases we further mapped our "Erlanger Diagnosis Code" to the CUIs (unique concept identifiers) of the National Library of Medicine's Unified Medical Language System (UMLS) Metathesaurus (8th edition) [9]. The UMLS Metathesaurus links alternative names for the same concept from different medical vocabularies together to a unique concept identifier, and on the other hand contains the information which term is to be used by which database for a given CUI. Thus, once we mapped our diagnoses to their CUIs we are now able to automatically use the respective preferred term in order to look up the diagnosis in other databases. Our database is currently linked to three other databases:

- MEDLINE (bibliographic database): We implemented a link to a publicly accessible WWW-version of MEDLINE on the Internet at the US National Center for Biotechnology Information (http://www.ncbi.nlm.nih.gov/PubMed/). A single mouse click brings users from any image of any given diagnosis in our database to the MEDLINE-database, performing an automatic search using the appropriate Medical Subject Heading for the respective disease.
- PDQ (Physicians Data Query) is a factual/expert database about cancer from US the National Cancer Institute [8]. It contains peer-reviewed statements on treatment, supportive care, screening, and prevention. For the dermatological diagnosis present in our atlas which are also covered by PDQ, users of the atlas may automatically query the PDQ-database (http://cancernet.nci.nih.gov) simply by clicking on a hyperlink, which contains the key used by PDQ for the given diagnosis.
- OMIM (Online Mendelian Inheritance in Man) is a factual/expert database about human genes and genetic disorders developed based upon the work of Dr. Victor A. McKusick and his colleagues [12] by the Center for Medical Genetics, Johns Hopkins University (Baltimore, MD) and National Center for Biotechnology Information, National Library of Medicine (Bethesda, MD). For the diagnoses covered in our atlas which have a genetic background we have provided an automatically generated hyperlink to the OMIM-database with an automatic search in OMIM for the respective disease.

Differential diagnosis mode

A differential diagnosis mode has been implemented by grouping diagnoses according to their morphology. In order to group the diagnoses, a textbook of dermatology [14] and the experience of senior dermatologists were used.

Survey among medical students

In order to evaluate the use of the electronic atlas in the educational setting, we distributed a questionnaire among 89 German medical students (fifth year) participating in an obligatory dermatology CBT (computer-based-training) -course, in which the electronic atlas was presented.

The first part of the questionnaire, to be filled in before the CBT-session, contained items exploring the students' computer literacy now and before their studies, asked about available hardware at home, the possibility of having access to the Internet and their areas of interest in different fields of informatics.

The second part of the questionnaire, to be completed by students after the CBT-session, contained items evaluating the online atlas as compared to other services offered on the Internet (electronic MCQ-questions, case reports, lecture scripts) and the question whether students would buy the atlas on CD-ROM.

The response rate was 100%. We excluded 21 questionnaires from analysis of the first part, as this group of students com-

pleted the first part the questionnaire after the CBT-course rather than before.

Patient questionnaire

Images from the atlas and our patient education system draws a high number of patients with atopic eczema to our website. In an ongoing experiment to collect medical data from patients and "normal controls" via the Internet, users visiting the website are encouraged to fill in an electronic questionnaire asking about several skin changes and stigmata related to atopy, e.g. dry skin. Answers are directly stored in a database for further analysis [2].

Results

We developed a database as international reference for dermatological images. The atlas currently contains about 3,000 images of high educational quality, covering more than 500 different diagnoses including rare diagnoses and pathological conditions on different skin types, which are not commonly found in ordinary textbooks.

In order to reach the aim of becoming an international resource, further image submissions from all parts of the world are welcome and encouraged.

The atlas is accessible from all over the world via the World Wide Web. We register more than 16,000 hits per day, the majority of which are coming from the US. The user-interface is currently available in German and English.

Use for Medical Education

Besides of being a reference resource for residents and specialists, the database is used for undergraduate training of medical students in their fifth year dermatological course.

We distributed an extensive questionnaire about computer-literacy and asking about other computer-related interests and prerequisites among medical students. Results of the survey were compared with a study about computer literacy among medical students conducted five years ago using a similar questionnaire [1]. Comparison of the results showed that computer literacy, technical prerequisites, attitudes towards computer-based training and interest in telecommunication among medical students (as a prerequisite for them using the atlas) improved remarkably during the last five years. For example, the word "online" was a known concept to only 44% of medical students five years ago, as compared to 90% in our recent questionnaire. Similarly, "email" was known to only 18% of students five years ago, as compared to 96% of todays students. Similarly, 96% of todays students knew the meaning of the word "Internet" and 78% knew the "World-Wide-Web" (both items were not asked five years ago). 50% of all students stated that they have access to the World-Wide-Web at the university or from home.

We conclude that the prerequisites for using an electronic atlas on the WWW do largely exist and that the online-atlas might be a valuable tool for student education. In addition, the atlas was rated better than other forms of education on the WWW, such as electronic lectures, MC-questions and case reports.

Patient education and use for epidemiological research

Using images from the database, an additional patient information system named Dermatology Internet Service (DermIS) was developed using static HTML-pages.

As our webpages attract a considerable number of patients suffering from diseases covered in our DermIS (currently focusing on skin cancer and atopic eczema), an experiment is currently conducted to use this popularity to obtain clinical and epidemiological data directly from patients and healthy controls who are visiting the website [2].

This is done by presenting form-based questionnaires to visitors. In order to confirm our hypothesis, that the quality of data obtained via the WWW is comparable with those obtained by traditional paper-based questionnaires, we include questions in our WWW-based questionnaires which have previously been delivered on a paper-based questionnaire to a population of patients in the clinical setting. Once the reliability of this novel method has been confirmed, one may use this method to reach a great number of patients from different countries in order to obtain "new" medical and epidemiological information from a population which is different than the usual patient population seen in out- and in-patient departments of university hospitals.

For example, we question patients about presence or non-presence of constitutional stigmata of atopy (dry skin, infraorbital fold, rarified eyebrows etc.) and obtain anamnestic data and other physical findings (illustrated by images from the electronic atlas), allowing us to calculate a prevalence of these findings among the population questioned.

Preliminary data indicate that this may be a novel, valuable method to obtain medical data from patients, especially if minimal forms of a disease exists, which are less frequently seen at university hospitals.

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