Health care professionals' image use and search behaviour

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Abstract. Images and visual information in general are produced in increasing quantities in health care settings. The variety of their use has increased as well. They are used for many tasks such as diagnosis, treatment planning, research, and teaching. Many health care institutions have started to make all images available in digital form as part of the electronic health record. Despite its importance, little is known about how health care professionals would like to access images or search for them, particularly for teaching or research. To learn more about the image use and search behaviour, we conducted a survey of image users at the University Hospitals of Geneva from March to May 2005. Methods: Six questions were asked to 18 individuals aiming to clarify how they would use and search for images in their roles as clinicians, educators, researchers, librarians, and/or students. Results: We found that many clinicians create their personal archives of images from clinical routine for further use. They usually add clinical information to illustrate interesting or typical cases, particularly for teaching and research. Image search for the various roles (clinician, lecturer, researcher, etc.) was not restricted to the hospital archive or teaching file. Many individuals searched for images on the Internet (Google and specialized scientific or university sites) but said that quality was a problem and was hard to judge. With respect to desired functionalities for image search, several subjects said they would like to search for images by pathology from the entire picture archive of the hospital (PACS). Some also mentioned that a search for similar cases to a current one would be very beneficial to aid diagnosis. The results of this survey will be used to create query topics for an international benchmark in medical visual information retrieval to investigate its value in the health care setting. The ImageCLEF benchmark currently contains four teaching files with over 50'000 images and aims to centre research in visual information retrieval on important medical search tasks.
Keywords: Medical image use, user behaviour, medical image retrieval, evaluation, benchmarking, survey

1. Introduction

Images are ubiquitous in modern medicine. They are produced for a variety of reasons in diagnosis, treatment planning, research, and teaching, and the quantities produced are rising rapidly [1]. The digital form makes these images also available for a large number of new tasks, as much information is stored in the images in connection with the medical record. Case-based reasoning and evidence-based medicine [2,3] could potentially benefit from the inclusion of images in the information search. Whereas textual search for medical information has been investigated for a long time [4,5], much less is known on the search behaviour for and use of visual medical information. New tools to store and make available anonymised cases such as myPACS[2] and MIRC[3] are getting increasing attention.

Content-based image retrieval based on visual image properties has been a very active research domain in computer vision for several years [6]. For the medical domain it has been proposed many times [7,8,9] and its potential to help in areas such as diagnosis and image management has been recognized. Still, despite a variety of research prototypes [10], only a single clinical study exists on the use of image retrieval as diagnostic aid [11]. A few active projects exist such as IRMA[4] and medGIFT[5]. Since 2004, a benchmark for medical image retrieval has existed in the ImageCLEF[6] initiative (Image Cross Language Evaluation Forum, [12]). In a first test, only visual capabilities of medical image retrieval systems were tested in 2004. In 2005, however, realistic query topics were created based on a user survey similar to the one described in this paper and carried out at Oregon Health & Science University (OHSU) with 15 persons [13]. With the goal of obtaining more and a wider variety of results, a similar study was planned and performed in the Geneva University Hospitals based on the initial results. Only when information needs are understood, real tasks can be created to evaluate retrieval systems.

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[2] http://www.mypacs.net/
[3] http://mirc.rsna.org/
[4] http://www.irma-project.org/
[5] http://www.sim.hcuge.ch/medgift/
[6] http://ir.shef.ac.uk/imageclef/

2. Methods

A qualitative user survey was planned and performed among 18 medical professionals from March to May 2005 on their image use behaviour and the way they search for visual medical information. The goal of the survey was to gain insight into the ways that visual information is currently treated and used, and to identify techniques that can be employed to meet new information needs. In addition, the results of the survey will be used to create realistic search topics for ImageCLEF 2006. Persons selected for the survey were chosen based on availability (students, radiology interns) and knowledge on their interest for image use (based on a previous survey on acceptance of digital radiology in the patient record). They were from many different departments of the University Hospitals of Geneva (Radiology, Surgery, Paediatrics, Library, etc.). Our goal was to recruit individuals who performed the following functions in the health care setting: Clinician, Lecturer, Researcher, Librarian, and Student. If a person had more than one function, the interviewer asked the questions separately for each function. Two interviewers shared the task to visit the surveyed individuals in their workplace and noted the ongoing discussion in the survey forms. Comments made on existing systems or new needs were regarded as extremely important.

The following questions were asked for each function of the persons separately:

- What kind of tasks do you perform in your daily work where images are useful for you?
- For each of these tasks, can you give us an example of what kind of image you are searching for?
- For each of these tasks, where do you search for the images? (Ordered by preference)
- When you search for images, how do you search for them?
- When you find an image, how do you decide whether one or another corresponds to your needs?
- What search tools or functions would be useful for you to search for images in addition to what is currently used?

For the 11 individuals who described themselves as clinicians, we substituted the following set of questions for the last one in the previous list, as we wanted to know more about how images from clinical use were reused and if the institutional teaching database Casimage[7] was used [14]. In this context we also asked about desired search methods for future image databases.

- Do you store images during your routine clinical work? How if not in Casimage? What are the advantages and disadvantages of Casimage? What search tools or methods would be useful for you in the future?

It is clear that some of the initial questions were not perfectly adapted for clinicians, as they often do not have a choice of images for a certain patient. Image search in this case is not necessary other than by patient name or identity. At the end of the survey, the results were collated in a text file and evaluated.

3. Results

A total of 18 professionals answered all questions and were kept for the final study. Among them, most had several roles, namely in diagnosis, research, and teaching together. This resulted in 30 forms being completed (Table 1). Among the 7 people with several roles, the average time for clinical work was 74%, research 16%, and teaching 10%. Interviews took 30 to 60 minutes.

Person no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average	Median	Total
Student		100	100	100	100														100	100	4
Librarian	100																		100	100	1
Lecturer														10	10	5	15	30	14	10	5
researcher						100	100					5	20	10	15	20	15	30	34	20	9
clinician								100	100	100	100	95	80	80	75	75	70	40	83	80	11

Table 1: overview of the work percentage of the interviewed persons for the various roles.

3.1. Students and librarians

The *librarian* said that the main task concerning images is to find them for users of the library of the medical faculty. Subjects were rather general and concerned topics such as HIV and images on the history of medicine and tropical diseases. The search was most often performed in databases of the University Hospitals such as Casimage and on commercial image datasets bought by the library on CD. The search methods were based on what the search programs offered and were either hierarchical or keyword-based. Relevance was not decided by the librarian but

[7] http://www.casimage.com/

rather by the person who asked for the images. New search methods concerned mainly the need for larger and freely accessible datasets either on CDs or better on the Internet to be searched directly with keywords and more options than currently.

The four *students* mentioned image search for the preparation of presentations for their internships, the creation of reports for courses, and the preparation of exams as being most important when the found or supplied material did not seem sufficient. All types of images were mentioned, including histological images, dermatological images, pathology images, or specific conditions such as a child with varicella or a pneumothorax. This demonstrated that a large variety of images were searched for, corresponding mainly to the subjects taught in the corresponding year of their training. As places to search for images, the most frequently used was the teaching file Casimage used by all four. Google, including Google image search, alltheweb, and other specialised sites including the Elsevier site of publications where the University has paid access, followed closely. The main search method was hierarchical search followed by keyword search on the web search engines. Quality of the images was judged by the resolution and the fact that the compression was not visible. Other factors including the colour and the size of the image were also mentioned.

Desired functionalities were:

- a "vertical" Google-like search engine specifically for medical images or even by medical domain such as pathology, radiology, etc. to search in a very focused image data set;
- an interface that allows searching for a self-drawn image or to mark regions in an image for further search of similar regions in other images;
- search by pathology or ICD code were considered as useful to quickly find desired information.

3.2. Lecturers

Five persons were partly in the category lecturer, only one of them above 30% of the time. Tasks with a need for images included mainly the preparation of slide presentations for teaching. However, it was also regarded as important to bring some real film x-rays to classes. In the context of teaching that included contact with simulated patients at the University of Geneva, images were also used on the computer in the electronic patient record. The types of images needed included mostly illustrations and graphics needed to create lively presentations. The principal image modalities mentioned by most lecturers included CT, x-ray, MRI, and photographs (pathology, dermatology). It was seen as important to have representative examples of a certain organ, system, or pathology.

The tools used most frequently include the PACS (Picture Archival and Communication System) and the electronic patient record (EPR), mentioned by almost all. The teaching file Casimage followed closely. On the Internet, three persons mentioned Google image search, one Auntminnie[8], and one eMedicine[9]. Alltheweb was mentioned twice as a source and one person mentioned specialised sites of universities and publishers in general. One person said he looked in books and scanned the images, while two persons said they use a home photo management program on their personal computer to store medical images and search them later in a directory structure.

Methods of search were most often keywords (mainly by pathologies) on the web and in Casimage. In the PACS, the search was usually done by patient name. The names were partly remembered and partly noted either on a PDA or on paper. Three times, it was mentioned that images were not found, as a name of a past patient was forgotten. In picture management systems, research was mainly by visual comparison and browsing in a directory structure.

Two persons responded to desired research methods in this section. The other persons with a partial task in teaching responded to desired search methods in their function as clinicians. One proposed query method was search based on a 3D atlas of the human body, where queries can be formulated based on body parts. Another desired method was to find the closest 5 pathologies to a certain pathology needed in clinical routine. Then, images that were representative for these pathologies could be retrieved to have a good comparison.

3.3. Researchers

Nine persons responded in their function as researcher to the survey. A large number of tasks were identified for which images are useful. Eight individuals said that they are needed to illustrate presentations for conferences and seven to illustrate scientific publications. More specific tasks that were mentioned included the segmentation of liver tumours and the reconstruction of 3D images from tomography slices. Two persons mentioned using images to select cases for studies and one to create a review for certain pathologies as image uses. The project for filmless radiology in Geneva was also mentioned. This project aims at removing all film-based production of images and at including

[8] http://www.auntminnie.com
[9] http://www.emedicine.com/

all images in digital form in the electronic patient record. As examples everyone mentioned images characteristic of a particular pathology. Standard x-ray was mentioned by almost all, CT and MRI by 4. Three persons mentioned photographs, PET and other nuclear medicine techniques were mentioned by two, echographies by 2 as well. Anatomic regions mentioned for search included mainly head, thorax, heart, abdomen and bones.
All researchers said they searched for these images in Casimage, whereas seven persons said they searched directly in the PACS or the EPR. Three individuals said they searched on the Internet, mainly using Google image search. Other search tools mentioned included DICOM CDs received from colleagues, images from publications such as Radiographics, other internal hospital sites, and personal collections on their own hard disks.
All individuals surveyed said they searched by keywords, mainly by pathology (7), on the Internet and in Casimage. In PACS and the electronic patient record, search was most commonly done by patient name. In Casimage, hierarchical search was also performed. In personal collections searching was often done by visual comparison, as no keywords were directly attached and searchable. On some web sites, search by ACR codes was possible and appreciated.
As quality criteria, all persons said they compared retrieved images visually and evaluated relevance by personal experience. Two persons said having no choice with the images they use for research as other persons choose them for their studies. Sometimes, important acquisition criterions were taken into account as quality criteria, such as slice thickness for tomographic images. On the Internet, known non-commercial sites were preferred as their content was regarded as more reliable. Resolution of the images was a criterion as well as the fact that the image is without artefacts such as movements of the patient.

3.4. Clinicians

Clinicians represented the largest group in this survey with eleven persons. The first four questions of the survey were not perfectly well adapted to their tasks, while the last questions about Casimage and desired search methods were of more interest to us of this group.
All persons said they used retrieved images for diagnosis and interpretation of a patient case. Most said they also used images for colloquia where interesting clinical cases were discussed. One said using retrieved images for treatment planning, one for the patient follow up, and one to decide on further examinations. All types of images were mentioned as being desired for retrieval, including CT, MRI, and standard x-ray images. Three persons used ultrasound, two arthroscopy, and one photographs. Almost all anatomic regions were mentioned, mainly depending on the clinical specialty of the person. All individuals mentioned PACS and the EPR as sources. Two mentioned CDs of external patients, one listed the comparison with cases in a personal collection, and two said they searched on the Internet to find similar images for comparing a case. For difficult cases, scientific articles were searched on the web to read more on a particular pathology. All subjects said they searched for images using the patient name; two persons said they used keywords (e.g., pathologies) when searching for more information on the Internet. Relevance was usually not a question, as there was often no choice of images. The images are most often controlled visually, so they do not contain any artefacts and all needed details are visible. Otherwise, an examination can be redone.
When asked about the storage of images from the clinical routine, ten individuals said they stored images routinely and one person said he did not store any images at all. Four persons said they stored images in Casimage and six not. One individual uses Casimage only to search. Among the six who did not use Casimage to store their images, the images were mainly stored locally in personal picture management software or in a directory structure on the hard disk. One said they had a personal static web site for image storage to make them accessible to others. Strong points mentioned about Casimage were the free availability and possibility to search for text as well as having text associated with images and cases. Simple use was mentioned as well as the link to the PACS. Other advantages included the access from the web and the quick search and use, the availability of ACR codes, and the hierarchy of cases. Weak points mentioned were the limited search capabilities, problems to include entire series of images and the export of cases for further use. The missing DICOM quality was also criticised by two persons and the fact that some cases are old and do not correspond to current techniques, as well as the fact that image names are replaced by a number at export time.
The most important parts for us in the survey are the comments and recommendation for search techniques that do not exist but are regarded as very useful:

- Search by pathology (10);
- Search by anatomic region (3);
- Search by visual similarity (2);
- Search by multi-modality combined to find similar cases;
- Indexation of the entire PACS by keywords regarding the pathology from the discharge letter;

- System that outputs a large number of images by pathology and anatomic region and that can further on do the classification automatically to give access to this hierarchy;
- More search in online books and articles possible, also to search for images to compare with;
- Creation of a visual atlas for most frequent cases in each discipline, by visual variation and similarity;
- Search on the Internet with a quality label for the images;
- Search for similar anomalies;
- Search of rather normal cases instead of very abnormal cases as in Casimage to be able to compare better with a current case.

These comments are important for us as they show possibilities for new search techniques. Still, it seems that medical professionals first need to use the techniques and supply feedback before larger applications are possible.

3.5. General issues and problems

One problem of the survey was to focus the respondents to answer a single question after another. Sometimes a more general discourse was carried out concerning general problems in digital medical imaging. Questions often had to be repeated, and answers had to be put into the section of another question than the one asked. Another difficulty for the subjects was the focus of the questions on one of the functions (clinician, research, teaching) as persons with several responsibilities tended to mix the functions in their responses. The purely digital radiology was partly criticized and more information on studies comparing digital and analogue radiology was asked for. Most concerns are with respect to speed of the PACS and also the functionality of the RIS (Radiology Information System).

4. Discussion and Conclusions

The results of this survey revealed that image management and search techniques have not kept pace with current medical image production techniques. They seem to be only rarely used in practice. Image storage facilities in the form of teaching files were not always used even when offered free of charge in a hospital. Some people did not know about these possibilities and others said that they were too complicated to use, as the interfaces did not allow all the desired functions. They were judged difficult or too slow to use. Personal use of digital cameras and management of private image collections might set standards on how the future of medical image management might be. New teaching files can get orientations from software to manage personal photographs.

The tasks performed with images and the ways to search for images vary strongly depending on the department of the person and on the role as clinician, lecturer, or researcher, which is not at all surprising.

Students search for images to illustrate study works and presentation or to prepare an exam and usually use the Internet to do so. They also know the local teaching file very well.

Researchers, on the other hand, have mainly presentations and publications in mind. Images used include pictures from clinical routine but also illustrations. Search is most often in the teaching file or in private collections, with the PACS being used fairly often.

Lecturers have a similar focus to researchers. Most images are illustrations and are used for slide presentations. These images are mainly found on the Internet but many as well in the local teaching file and a few directly in the PACS system. This group of users would particularly profit from visual access methods to large datasets to refine search and complement text-based retrieval. Copyright issues concerning images found on the Internet were not taken into account at all.

Most interesting for us is the group of *clinicians* and their desired information needs. With respect to diagnostics they rarely search images but use the patient images they have available. Still, they say that it would be extremely useful to be able to search the PACS for the same or similar Pathologies. Visual search was also mentioned as important to search for similar cases, although other than visual factors need to be taken into account, as well.

The main results from this qualitative survey are:

- Most clinicians do store images from routine or references to past cases for future use. If this functionality is not supported by the institution this is done on personal computers and often in a simple directory structure;
- Available applications for teaching files are not always used, and rather the quickest way to store a case is applied such as storage on a personal computer while not taking into account future search problems. Applications for home photos are regarded as good and easy to manage also for medical images in a professional context.
- Many persons do not know much about the existence of visual search methods for medical images;

- Keyword search or hierarchical search in a known structure is the most common search method for tasks other than diagnostics. Diagnostic access is mainly done by patient name;
- Most persons use the Internet to find images as a second option to local databases; quality is regarded as a problem and experience is the main factor to evaluate image quality;
- Most often desired new method for search is the search by pathology, allowing to compare an actual case to, preferably on the entire PACS;
- Visual search is mentioned a few times as important possibility to find similar images and cases to a current case, to optimise images for teaching but most practitioners do not believe that this technology is mature.

Limitations of the survey include the fact that only 18 persons took part. While not necessarily completely representative of all users, the responses were very rich and provided us a good first idea about problems and needs. One of the biggest problems of this survey was the lack of time of medical professionals and the number of other surveys that they are asked to do. Twice, the questions were answered while performing other tasks, so the goal was not having profound answers but rather to finish the survey quickly.

With respect to generating search tasks for the ImageCLEF benchmark, it is clear from these findings that the tasks need to be oriented towards textual rather than purely visual topics, with visual tasks being geared towards introducing the technology to clinicians. When looking at the most often mentioned axes, the search for pathology seems extremely important. Other axes mentioned are the search for certain modalities (this can be done in visual form, often better than by text as the modality often does not appear in the text) and anatomic region as well as visual abnormalities in images, where visual search might be of help as well.

Further work is still needed to advertise the importance of shared teaching files for an institution to create a knowledge base. Even more work will be needed to make visual search tools used in hospital practice. First domains are most likely teaching and research, but diagnostics does have most potential benefits. By creating realistic tasks for the evaluation of visual retrieval methods based on information needs of medical professionals, we hope to create techniques that perform better and have a higher chance of getting acceptance in the medical domain.

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