Management of Medical Multimedia Data

The retrieval of medical multimedia data by its content as a method to search similar cases

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Digital production of medical data in almost all medical institutions is increasing exponentially (The Geneva University Hospitals' Radiology produced on average 12'000 images per day in 2004, 40'000 in 2006, and over 70'000 in 2007). These data are an integral part of aiding diagnosis and for treatment planning. At the same time as the data production is increasing the variety of data produced and diagnostic tests available are increasing as well, creating sometimes an overload of information for the clinicians. All data are now directly accessible in the electronic patient record and are not principally reviewed by specialists in radiology or nuclear medicine as this was the case in the past [1].
Patient data is now accessible in digital form, so it can also be re-used to exploit the important information stored in it that can help clinicians for similar patients in the future [2]. This secondary use of medical data is currently a much discussed topic in medical informatics and a large potential is definitely available. Legal guidelines still need to be developed for such a data reuse respecting the private sphere of patient.

Multimedia Data Sources

When thinking about the electronic patient record, structured textual data comes to the mind first, but the situation is much more complex as graphics, images, 3D volumes and video streams are equally available and need to be analysed. Here is a short list of sources commonly stored in medical patient records that could profit from automatic visual analysis of the data here ordered by complexity:

- free text (release letter, anamnesis, …) often stored in pdf format, sometimes scanned;
- one-dimensional signals that are often time-based such as ECG (Electrocardiogram) and EEG (Electroencephalogram);
- two-dimensional signals or images: x-rays, dermatology images, pathology images, …;
- series of images belonging together such as full body photographs for dermatology;
- series of 2Dimage slices such as tomographies (CT, MRI, PET, SPECT);
- videos: sleeping laboratory, cardiology, endoscopy, …;
- 3-dimensional images: reconstructions from tomographic images or ultrasound creating surface or volume images;
- 4-dimensional images: flow simulations based on 3D datasets, for example to show flow in aneurisms, or functional MRI (fMRI);
- n-dimensional combinations of modalities: for example a 5D PET/CT simultaneously combining anatomical, functional and temporal information with a 3D reconstruction..

This list can only give a few starting points and the problem of treating videos in the Picture Archival and Communication System (PACS) is currently only starting. The Geneva sleeping laboratory, as an example, produces currently over 1000 DVDs of video data per year and no automatic analysis of these data is performed at the moment.

Content-Based Information Search

Content-based image retrieval (CBIR) has been an extremely active research domain [3] in the non-medical field as data production through the cheap availability of digital cameras has risen strongly. Many of the image archives had little or no annotation, creating the need for navigating in the large data sets directly by the visual content of the items/images and not through textual annotation.

In the medical field CBIR was proposed very early [4] but even after many years of research only a few prototypes exist in clinical practice, although a first clinical study showed a significant gain in diagnostic quality [5]. An extensive review of current image retrieval techniques can be found in [6].

Generally, visual methods attempt to find visually similar images to an example image supplied by the clinicians. This allows searching for similar cases based on the visual data. Other clinical data, or the context in which the image was taken, also needs to be taken into account. For teaching searches such as "Show me xray images similar to tuberculosis" can easily be perfomed with a visual example but only hardly with text.

Visual features

Instead of using textual data for retrieval CBIR automatically analyses the image content and extracts so called features that represent the images for retrieval. These are supposed to be similar to words extracted from free text but in general there is an information loss when automatically extracting visual features.

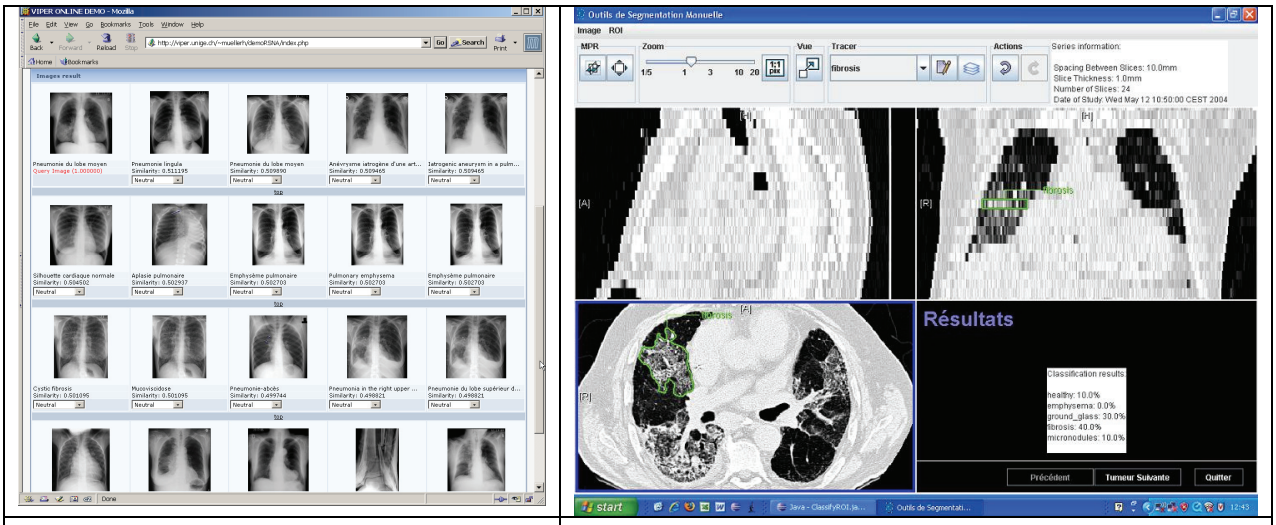
The most commonly used visual features are:

- color or grey level features globally in the form of a histogram or locally in image regions;
- texture features describing the repetitiveness in local homogeneous patterns, for example for describing the texture of lung CTs to aid the diagnosis of interstitial lung diseases;
- shape features describing the form of identified objects often after a segmentation of the image into homogeneous regions;
- salient points or interest points have emerged as a powerful features over the last years including a certain invariance with respect to small changes in the images, for examples rotations, shifts, or intensity changes;

All these features describe the content of the images itself, albeit with an information loss. To obtain good retrieval results other clinical data or the context in which the images were taken need to be taken into account, such as the age of the patient, the weight or the medical use.

User interfaces

An extremely important aspect of visual search is the user interface with which the clinician communicates. In most interfaces a query is performed with an example image and then the most similar Images are shown in decreasing order of similarity comparable to a search engine (see Figure 1a). Newer interfaces also allow marking regions of interest in the images to concentrate the analysis and search on a small part of the image, only (see Figure 1b).



(a) (b)

Figure 1: Two user interfaces for image retrieval, one using a single image as an example (a) and a second one allowing the annotation of regions in a 3D volume for retrieval (b).

Conclusions and outlook

The electronic patient record is increasingly becoming a multimedia patient record. These new data sources need to be included into an automatic data analysis circle to fully exploit the knowledge stored in them.

Content-based image retrieval in connection with clinical data has the potential to help particularly less experienced clinicians in the decision making and has the potential to exploit data stored inherently in past cases in an efficient way. Still, to make these tools a success access to large data repositories needs to be possible and this includes organisational as well legal changes in the system. Once these barriers are taken, image retrieval need to take into account visual features as well as the entire clinical context of the patient to retrieval similar cases to aid diagnosis and treatment planning and to extract knowledge from the patient record including visual information on the stored data.

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Abstract

This article provides a short introduction to the retrieval of medical multimedia data by its content and not through access via patient name or textual annotation. This content-based access method can reach part of the knowledge inherently stored in medical case reports that often include multimedia data.

Basis for these methods is the multimedia electronic patient record that gives access to the entire data on a patient in digital form, thus allowing further automated analysis. The data produced for diagnosis in general are getting increasingly varied and at the same time all clinicians are now getting access to the entire data. Beforehand, much of the visual data was reviewed by specialists such as radiologists only. This change in public also requires the creation of new tools aiding with the interpretation of increasingly complex healthcare data.