Mobile web-based technology for medical image retrieval

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Abstract: *The processing of medical image data is playing an increasingly important role among the applications of computer science in the field of medicine. Current medical imaging techniques such as X-Ray, computer tomography or ultrasound produce an increasing amount of digital images every day. Thus the need for efficient retrieval of images of particular interest is becoming very urgent. Two different approaches are used for the representation of images: the metadata-based and the content-based approaches. Manual describing and annotating of every image is time-consuming and inefficient. In this paper we present a prototype of medical image retrieval tool for both computer tomography and X-Ray medical images which can be accessed by any portable device with conventional web browser. Experimental evaluation of the retrieval performance of the tool confirms feasibility of the technology for serving as a possible research and diagnosis tool for accessing medical image databases remotely.*

Keywords**:** content-based image retrieval, web-based medical imaging, X-Ray, computer tomography.

1. INTRODUCTION

Content-based image retrieval (CBIR) is the process of retrieving images by directly using image visual characteristics. In comparison to text-based image retrieval which uses textual language to describe image content, it has significant limitations, especially in medical domain, since image data cannot be fully described texturally. Traditionally, CBIR uses visual characteristics, such as color, texture or shape to represent image content and to retrieve images from databases which are visually similar to a query image. One of the CBIR challenges is to bridge the semantic gap between low-level features extracted automatically from images by computers and the high-level interpretation by human. Therefore CBIR for medical databases has the potential to assist clinical decision-making, research, training and easy-to-use retrieval of medical images [1].

In this paper, we describe our web-accessible CBIR prototype tool which operates on groups of medical images. To use our tool, the user selects a query image in order to find similar one. The tool calculates the feature vector of the query image and compares it with the pre-computed feature vectors of images stored in the database. The returned images are ranked by the degree of similarity to the query feature vector and presented along with associated group information.

In order to allow the final prototype tool to be accessed remotely for either diagnostic or learning purposes, it is designed and implemented using a web server technique with scripting language support.

2. DATABASE AND TASK DESCRIPTION

The first image dataset consists of 6594 images sub-sampled from image databases obtained in framework of mandatory national X-ray screening program currently running in Belarus. Of these, 3 groups of images with different patient age (22-23, 42-43, 62-63 years old respectively) were selected, equally men and women. The image size was 560x576 pixels, 16 bits of intensity resolution. The second image database contains 843 computer tomography (CT) slices taken from 73 patients separated into 3 sub-groups by anatomical areas (heart, liver and the lung). The image size was 512x512 voxels with 12 bits of intensity resolution. Further details on the test image databases are given in Table 1. Some examples of original images of both databases are shown in Fig. 1.

Table 1. Image databases used in the prototype tool.

X-Ray database		**CT database**	
Class (age group)	**Quantity**	**Class** (anatomical area)	**Quantity**
22-23	2198	heart	234
42-43	2198	liver	485
62-63	2198	lung	124
Total	**6594**	**Total**	**843**

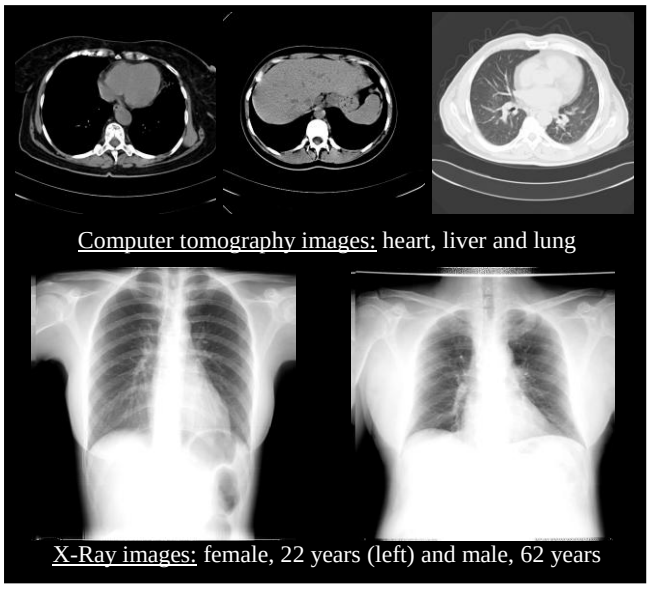

Fig.1 – Examples of images from computer tomography and X-Ray databases.

3. IMAGE REPRESENTATION

One of the common features implemented in CBIR systems is finding similar images. To accomplish this, the content should first be described in an efficient way, e.g. the so-called feature extraction should be performed. Usually the visual content of images in the database is described by feature vectors, possibly of different sort.

Selecting a proper type of image descriptors is vital for system performance. Since original images are gray level, our tool analyzes not color but texture and its statistical features. In particular, extended co-occurrence matrices for image description were used: triplets unlike pairs of pixels in classical Haralick matrices [2]. Suggested type of co-occurrence matrix is a matrix of relative frequencies $P(i,j,k,d_1,d_2,d_3)$ with which the three pixels with gray levels i,j and k respectively occur in the image by distances d_1,d_2,d_3 apart. Every descriptor can be represented as a triangle with gray levels in its corners. Descriptors are covering entire image and represent statistical distribution of spatial relationships of gray level intensities. Consideration of the additional third pixel increases feature space and thereby enhances the sensitivity to medical texture.

In our experiments we used triangle-shaped descriptors with side sizes 1, 3 and 5 pixels. Increasing descriptor's size would lead to losing correlation between pixels and thereby local texture features. Extended co-occurrence matrices were calculated with 16 bins of gray levels. Invariance for both rotation and reflection is achieved by matrix reduction to a triangular form [3]. In other words sequence order of intensities at sides of triangles becomes unimportant. To decrease the number of elements in matrix and simplify data so-called feature vector was extracted from the co-occurrence matrix. Low sensitivity to image size was achieved after feature vector normalization by sum of the elements.

4. APPLICATION ARCHITECTURE

To provide a remote access for content-based retrieval, our application is implemented as a web-server with dynamic pages (PHP scripting language support). The server uses open communication standards and open source software, and decouples the graphical user interface from the core indexing and retrieving algorithms. As shown in Fig. 2, the prototype system architecture consists of two sides.

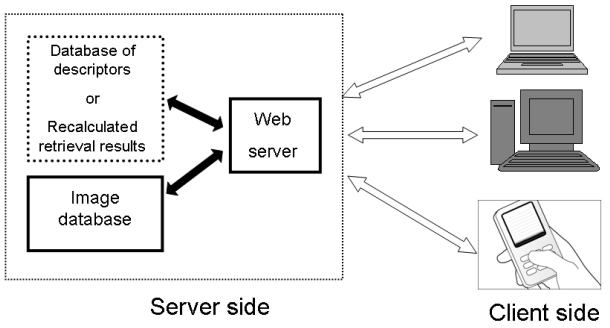

Fig.2 – Prototype system architecture.

Client side can be either computer or any other portable (wireless) device with conventional web browser (Fig. 3). User is provided with graphical interface for specifying query image or query type. Query images can be selected from the image repository randomly (the system will choose one for the user) or by user specification. Example of interface for X-Ray image retrieval is shown in Fig. 4.

Fig.3 – Portable wireless device with prototype medical image retrieval tool running in an internet browser.

Server side contains a web server with access to image and descriptors database. Server's software uses database of descriptors to find similar images and sort them out in descending order. We implemented our tool for CT and X-ray image databases. The images used for testing are "ground truth" images referring to a specific group (age and gender for X-Ray or anatomical area for CT databases).

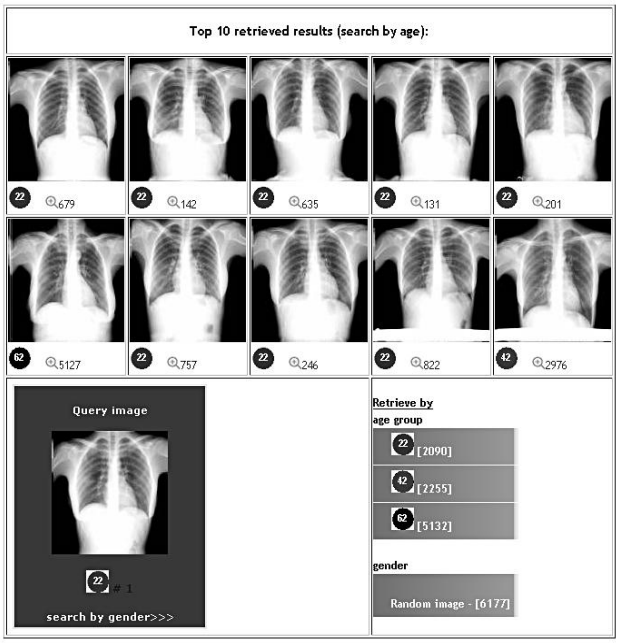

Fig.4 – Example of graphical user interface.

5. RESULTS

Aiming to validate the proposed model through the demonstration of performance and quality gain in the image content retrieval process, a sequence of experiments has been performed. Image comparisons supposed calculating L_1 distances between their feature vectors. Every image was submitted as a query and the accuracy was estimated for the first 30 retrieval results.

Retrieval results for *X-ray* images are shown in Fig. 5.

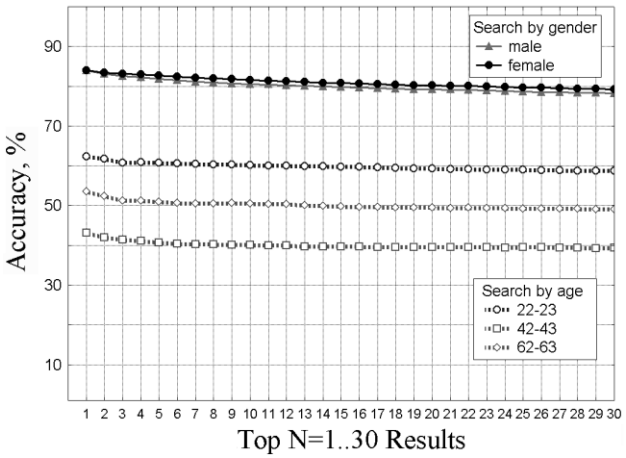

Fig.5 – Retrieval results for X-ray database.

When searching by *age* the mean accuracy for 22-23 years old group was 60%, 42-43 – 40%, 62-63 – 50% and practically stayed constant for the rest of retrieval results. When searching by *gender* the mean accuracy approximately linearly falls from 84% at the 1st result to 78% at the 30th retrieval result for male patients. Similar accuracy behavior can be observed for female patients too.

In case of *CT* images retrieval by *anatomical area* the accuracy was almost ideal (the worst one was 99.7%). Such almost perfect retrieval results can be explained by relatively high difference between classes of the original CT images.

5. CONCLUSION

In this paper we have presented a prototype CBIR tool that retrieves similar images from CT and X-Ray image databases. It uses extended co-occurrence matrices as descriptors of image texture. The tool has a distributed architecture with the advantages of web technologies and can be accessed with web browser. Preliminary assessment of the prototype system has demonstrated its potential to serve as a possible research and diagnosis tool, and to improve the efficiency of current medical decision support and picture archiving systems.

Content-based visual information retrieval has a large potential in the medical domain. Content-based methods can be used on a large variety of images and in a wide area of medical applications. We are working on several aspects to further improve the retrieval performance by looking for appropriate type of image descriptors, image comparison techniques [4] and new types of queries like groups of images [5].

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6. REFERENCES

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