WEB-BASED MEDICAL IMAGE RETRIEVAL SYSTEM

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ABSTRACT

Among the applications of computer science in the field of medicine, the processing of medical image data is playing an increasingly important role. With medical imaging techniques such as X-Ray, computer tomography, magnetic resonance imaging, and ultrasound, the amount of digital images that are produced in hospitals is increasing incredibly fast. Thus the need for systems that can provide efficient retrieval of images of particular interest is becoming very high. The two different approaches used for the representation of images are: the metadata-based and the content-based approaches. For very large database personally describing and annotating every image with text indices is time-consuming and impractical. In this paper we propose a content-based image retrieval system with parallel retrieval engines to achieve higher retrieval performance and efficiency.

1 INTRODUCTION

Content-based image retrieval (CBIR) is the digital image searching problem in large databases that makes use of the contents of the images rather than relying on human-input textual information such as captions and key-words [1]. For very large databases or automatically generated (surveillance systems, medicine etc.) images, personally describing and annotating every image is time-consuming and impractical. Rather than relaying on manual indexing and text description for every image, low-level visual features automatically extracted are used for representation of the image content. Content-based image retrieval makes use of the visual contents of an image to represent and index the image. Color, shape, texture, and spatial layout are the typically used contents [2], [3], [4].

The main goal in CBIR system is searching and finding similar multimedia items (in our case images) based on their content. To accomplish this, the content should first be described in an efficient way, e.g. the so-called indexing or feature extraction. Then fast and accurate retrievals among the multimedia collections can be done according to the content description. Figure 1 illustrates a general overview of a CBIR system where "offline" indexing phase is displayed in the bottom part. Usually the visual contents of the images in the database are extracted and described by multidimensional feature vectors. A feature database is formed using the feature vectors of the images in the database. The "online" content-based retrieval is displayed in the upper part. Users provide the retrieval system with query example images, which are used to retrieve images. The system then extracts the feature vectors from the example images. The similarities/distances between the feature vectors of the query example and those of the images in the database are calculated. The online and offline phase interact with a collection of multimedia items (images, videos, etc.) from a multimedia database. The query provided by the user can be an example image, region, sketch, humming, or text [5].

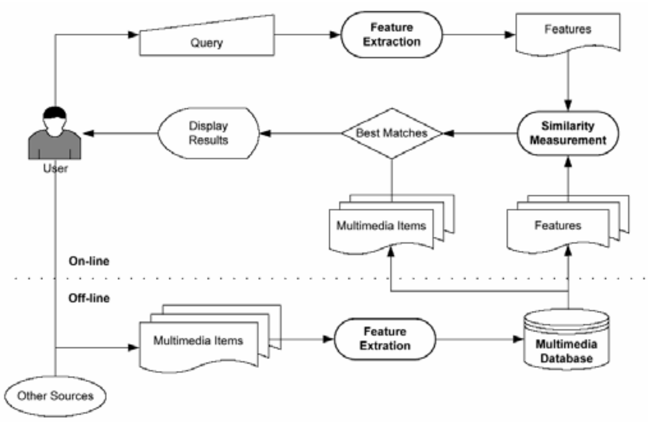

Figure 1: *Overview of general CBMR structure.*

2 APPLICATION OF CONTENT-BASED IMAGE RETRIEVAL IN MEDICINE

Content-based image retrieval is applicable in various areas. One of the potential application area is medical CBIR [6]. The growing number of digital image acquisition and storage systems in clinical routine such as: X-ray, X-ray computed tomography (CT), magnetic resonance (MR), magnetic resonance spectroscopy (MRS), single photon emission computer tomography (SPECT), positron emission tomography (PET), ultrasound, electrical source (ESI), electrical impedance tomography (EIT), rises demands for new access methods. Content-based image retrieval has been proposed by the medical community for inclusion into picture archiving and communication systems (PACS) [6]. The idea of PACS is to integrate imaging modalities and interfaces with hospital and departmental information systems to manage the storage and distribution of images to radiologists, physicians, specialists, clinics, and imaging centers. A crucial point in PACS is to provide an efficient search function to access desired images. The common file format for medical images is DICOM [7], which contains some additional information regarding image modality, acquisition device, and patient identification in its header along with raw image data. Image search in medicine is currently carried out according to the alphanumerical order of textual attributes of images. However, the information which users are interested in is the visual content of medical images rather than that residing in alphanumerical format. The content of images is a powerful and direct query which can be used to search for other images containing similar content. Hence, content-based access approaches are expected to have a great impact on PACS and health database management. In addition to PACS, medical imaging databases that are unconnected to the PACS can also obtain benefits from CBIR technology. CBIR technology can benefit any work that requires the finding of images or collections of images with similar contents. In medical research, researchers can use CBIR to find images with similar pathological areas and investigate their association. In medical education, lecturers can easily find images with particular pathological attributes, as those attributes can imply particular diseases. In addition, CBIR can be used to collect images for medical books, reports, papers, and CD-ROMs based on the educational atlas of medical cells, where typical specimens are collected according to the similarity of their features, and the most typical ones are selected from each group to compose a set of practical calibrators.

3 EXISTING MEDICAL CBIR SYSTEMS

Although content-based image retrieval has frequently been proposed for use in medical image management, only a few content-based retrieval systems have been developed specifically for medical images. These research-oriented systems are usually constructed in research institutes and continue to be improved, developed, and evaluated over time. This section will introduce several major medical content-based retrieval systems.

ASSERT - Automatic Search and Selection Engine with Retrieval Tools [8] is developed by Purdue University, Indiana University, and University of Wisconsin Hospital, USA. The system uses image database form by High-Resolution Computed Tomography (HRCT) of lung. The ASSERT system uses a physician-in-the-loop approach to retrieving images of HRCT of the lung. This approach requires users to delineate the pathology-bearing regions and identify certain anatomical landmarks for each image. This system extracts 255 features of texture, shape, edges, and gray-scale properties in pathology-bearing regions. A multi-dimensional hash table is constructed to index the HRCT images.

CasImage is another medical CBIR system [9]. The system is developed in University Hospital of Geneva, Switzerland. The image Database contains variety of images from CT, MRI, and radiographs, to color photos. The CasImage system, which has been integrated into a PACS environment, contains a teaching and reference database, and the medGIFT retrieval system, which is adapted from the open-source GIFT (GNU Image Finding Tool) [10]. The medGIFT retrieval system extracts global and regional color and texture features, including 166 colors in the HSV color space, and Gabor filter responses in four directions each at three different scales. Combinations of textual labels and visual features are used for medical image retrieval.

IRMA (Image Retrieval in Medical Applications) system [11] developed by Aachen University of Technology, Germany uses various imaging modalities. The IRMA system is implemented as a platform for content-based image retrieval in medical applications. This system splits the image retrieval process into seven consecutive steps, including categorization, registration, feature extraction, feature selection, indexing, identification, and retrieval.

NHANES II (The Second National Health And Nutrition Examination Survey) [12] is a system developed by National Library of Medicine, USA. 17,000 cervical and lumbar spine X-ray images form the database. This system contains the Active Contour Segmentation (ACS) tool, which allows the users to create a template by marking points around the vertebra. If the segmentation of a template is accepted, the ACS tool will estimate the location of the next vertebra, place the template on the image, and then segment it. In data representation, a polygon approximation process is applied for eliminating insignificant shape features and reducing the number of data points. The data obtained in the polygon approximation process represent the shape of vertebra. Then, the approximated curve of vertebra is converted to tangent space for similarity measurement.

3 SYSTEM OVERVIEW

The proposed system has two main parts: a control access module and a content-based indexing and retrieval module. Figure 2 illustrates the overall system architecture. The system is build by ASP .NET, powerful web application framework that can be used for building dynamic web sites, web applications and XML web services. The client module performs validations and basic computing operations such as: query image selection, insertion of images into the archive and displaying the results obtained from the query process. The server module consists of image processing and feature extraction sub module which is basically C++ libraries used for generation of the feature vectors. The Image and Diagnosis DB sub module contains medical images divided in separate classes. The Content-based Retrieval sub module performs the similarity matching between the example image and the images form the database, dataset selection and training. In the following section we will briefly describe the types of features used in our experiments: low resolution pixel map and blob representation which is a middle-level image feature representing shapes of objects.

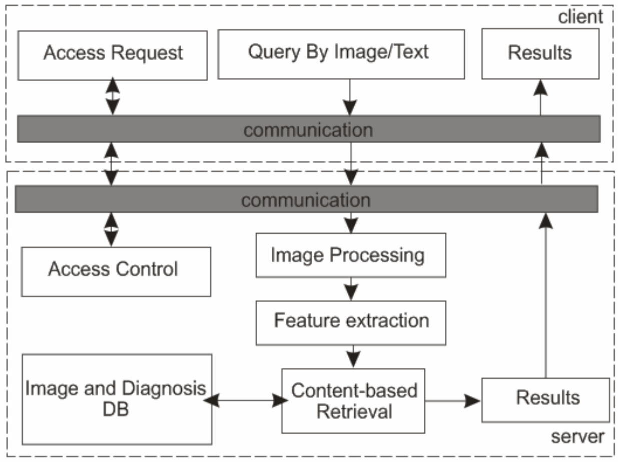

Figure 2: *System architecture.*

3.1 Features

Content-based access to images relies on numerical features that are computed from the pixel values. In our system we use several features for representing texture and shape.

The edge histogram descriptor represents the spatial distribution of five types of edges (four directional edges and one non-directional). It consists of local histograms of these edge directions, which may optionally be aggregated into global or semi-global histograms. The image is divided in 4x4 non-overlapping sub-images where the relative frequencies of five different edge types (vertical, horizontal, 45^0, 135^0, non-directional) are calculated by using 2x2-sized edge detectors for the luminance of the pixels. The descriptor is obtained with a nonlinear mapping of the relative frequencies to discrete values [13].

One of the most popular signal processing based approaches for texture extraction has been the use of Gabor filters. It has been proposed that Gabor filters can be used to model the responses of the human visual system. A range of filters at different scales and orientations allow multichannel filtering of an image into texture features. The feature is built by filtering the image with a bank of orientation and scale sensitive filters and computing the mean and standard deviation of the output in the frequency domain [14].

The use of object shape is one of the most challenging problems in creating efficient CBIR. The object's shape plays a critical role in searching for similar image objects. That shape often carries semantic information follows from the fact that many characteristic objects can be visually recognized solely from their shapes. In our experiments we used the Region-Based Shape Descriptor which is part of the MPEG-7 standard [15]. The region-based shape descriptor uses region moments which are invariant to transformations as the shape feature. It can describe complex objects with multiple disconnected regions as well as simple objects with or without holes. It gives a compact description of multiple disjoint regions simultaneously, allows for splitting of an object during segmentation into disconnected sub-regions, and is robust to segmentation noise (e.g. salt-and-pepper noise).

Figure 3 shows the diagram of the proposed parallel retrieval engines. Every retrieval engine use independent image features and descriptors. The first stage in the retrieval process is evaluation of the results produced by the retrieval engines. The images that are present in the results of half of the retrieval engines are selected as positive results. The next step includes feature fusion and training. The selected image features from the previous stage are mixed to form one feature vector. These positive images and their feature vectors are used to form an initial training sets and the query is expanded using these images. The training phase is done by using SVM [16].

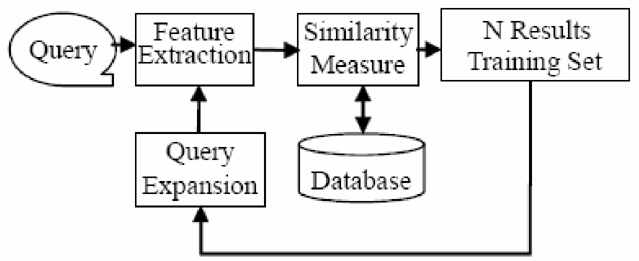

Figure 3: *Query expansion and training dataset formation*

4 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. The database that was used in the experiments contains 12.000 images divided in 116 classes. For the expirements we have chosen 20 different query samples. We evaluate the retrieval process by counting the number of positive examples. The obtain results show that the retrival performance is better because by the merging process we eliminate the negative examples that are produced using only single retrieval feature.

5 CONCLUSION

We have created a web-based application for storage, retrieval, manipulation, and annotation of medical images and medical records for the development and evaluation of CBIR methods. The application has ability to input and store multiple feature sets and result sets for each image. The advanced querying capabilities provide rapid analysis and comparisons radiologist techniques, medical image features and CBIR techniques.

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