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Content Based Image Retrieval For Medical Images Using Generic Fourier Descriptor

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Abstract

Content-based image retrieval (CBIR) has been one of the most vivid research areas in the field of computer vision, and substantial progress has been made over the last years. Efficient content-based image retrieval in the medical domain is still a challenging problem. CBIR systems are currently being integrated with picture archiving and communication systems for increasing the overall search capabilities and tools available for radiologists. Shape is one of the fundamental visual features in content-based medical image retrieval. This paper describes Generic Fourier shape descriptor and medical image retrieval system using Generic Fourier shape descriptor. The retrieval performance of this shape descriptor is tested using a large medical image database and measured using commonly used performance measurement.

Keywords: CBIR, Generic Fourier Descriptors, Precision and Recall, Medical Images, PACS.

Introduction

Due to the rapid development of digital and information technologies, more and more images are generated in digital form. This requires image to be effectively and efficiently described to facilitate automatic searching. Content Based Image Retrieval (CBIR) [1,2,3] is a technique whereby images are described by a few top level features such as color, texture, shape or the combination of them.

There is an increasing trend towards the digitization of medical imagery. Medical image databases are key components in future diagnosis and preventive medicine. With the emergence of Picture Archiving and Communication Systems (PACS) there

has been a great interest to integrate all the information related to patients in unified systems. PACS should incorporate techniques allowing to retrieve the medical images in a timely manner for improving the quality and efficiency of care processes.

CBIR systems have been found useful in medical applications and the medical domain is currently cited [4,5,6] as one of the principal application domains for content based technologies. Adding CBIR capabilities to PACS makes it more powerful to assist diagnosis, allowing easier and more efficient manipulation and organization of stored images. Besides diagnostics, teaching and research especially are expected to improve through the use of visual access methods as visually interesting images can be chosen and can actually be found in the existing large repositories.

Shape is the fundamental visual features in CBIR. Various shape techniques exist in the literature, these methods can be classified into two categories: Region-based and Contour-based. Contour-based shape descriptors use only the boundary information, ignoring the shape interior content. Examples of contour based shape descriptors include Fourier descriptors [7], Wavelet descriptor [8], Curvature scale space descriptor [9]. Since they are computed using only boundary pixels, their computational complexity is low, but they cannot represent shapes for which the complete boundary information is not available.

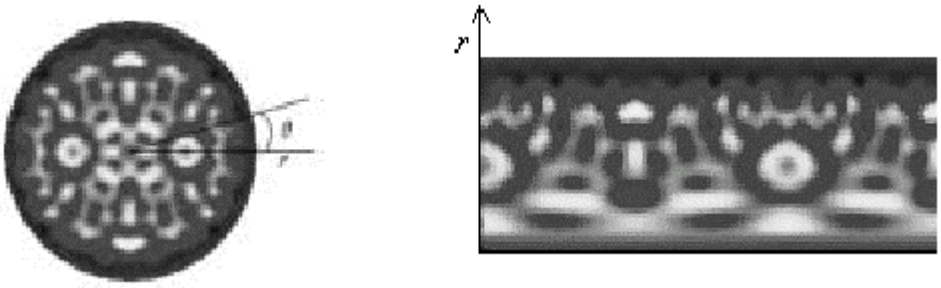
Region-based shape descriptors exploit both boundary and interior pixels of the shape. They are applicable to generic shapes and are more robust to noise and shape distortions. Among the region-based descriptors, moments have been very popular. These include Geometric moments, Invariant moments, Zernike moments Legendre moments etc.

Generic Fourier Descriptor(GFD) is one of the region-based shape descriptor. It has been studied that among the various region-based shape descriptor GFD has the highest retrieval performance[10]. This paper describes the medical retrieval system using GFD. The medical image retrieval system has been developed to test this. The retrieval performances have been evaluated by the precision and recall measures.

The paper has been organized as follows: Section 2 covers the Generic Fourier Descriptor. Section 3 gives the medical image retrieval system. Section 4 gives the experiments and results. Section 5 gives the conclusion.

Generic Fourier Descriptor (GFD)

Generic Fourier Descriptor proposed by Zhang [11] is extracted from spectral domain by applying 2-D Fourier transform (FT) on polar raster sampled shape image. Shape analysis using FT is backed by well developed and well understood Fourier theory. However, it is not desirable to acquire shape features using FT directly, because the acquired features are not rotation invariant. Therefore, a modified polar FT is proposed by treating the polar image in polar space as a normal two-dimensional rectangular image in Cartesian space. Fig 1.(a) is the original image in polar space. Fig. 1. (b) is the rectangular polar image plotted into Cartesian space. If 2-D FT is applied on this rectangular image, the polar FT has the similar form to the conventional 2-D discrete FT in Cartesian space.



(a) (b)

Figure 1: (a) original shape image in polar space; (b) polar image of (a) plotted into Cartesian space.

For a given image f(x,y) the polar FT is defined as

$$PF(\rho,\phi)=\sum_{r}\sum_{i} f(r_i,\theta_i)\exp\left[j2\pi\left(\frac{r}{R}\rho+\frac{2\pi i}{T}\phi\right)\right] \quad (1)$$

where $0\le r=\left[(x-x_c)^2+(y-y_c)^2\right]^{1/2}<R$

$\theta_i=i(2\pi/T)\,0\le i<T$

(x_c,y_c) is the center of mass of the shape.

$0\le\rho<R, 0\le\phi<T$

R and T are the radial and angular resolutions

The determination of number of ρ and ϕ for shape determination is physically achievable because shape features are normally captured by the few lower frequencies. The acquired polar coefficients are translation invariant. Rotation and scaling invariance are achieved by the following normalization[25]:

$$GFD=\left\{\frac{PF(0,0)}{area},\frac{PF(0,1)}{PF(0,0)},\ldots\frac{PF(0,n)}{PF(0,0)},\ldots\frac{PF(m,0)}{PF(0,0)},\ldots\frac{PF(m,n)}{PF(0,0)}\right\} \quad (2)$$

where area is the are of the bounding circle the shape resides.

m is the maximum number of the radial frequencies selected.

n is the maximum number of angular frequencies selected.

For efficient shape representation, only a small number of GFD features are selected for shape representation. In our implementation, 36 GFD features reflecting 4 radial frequencies and 9 angular frequencies are selected to in the shape.

Medical Image Retrieval System

CBIR system consists of two major steps. The first one is the feature extraction, where a set of feature is generated to represent the content of each image. The second one is the similarity measurement where a distance between the query image and each image in the database is computed using their feature vectors. For all images in the

database the features are extracted and stored in the database. Given a query image, such a system first extracts its feature vector and then compares it to those of the images stored in the database. The images of the database are ranked according to the distance of their feature vector to the query image. As a result the top N most similar images can be retrieved from the database. Figure 2 presents the block diagram of the retrieval system.

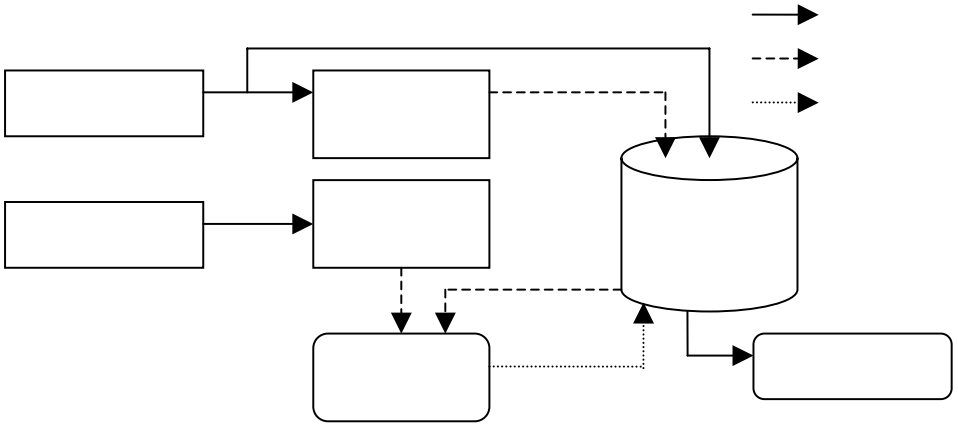


Figure 2: Block diagram of medical image retrieval system

Feature Extraction

The images are segmented before feature extraction. The shape feature is extracted using GFD shape descriptor method. The extracted shape features are stored in the database for all the images in the database.

Similarity Measures

For shape based image retrieval, the image feature extracted is usually an *N*-dimensional feature vector which can be regarded as a point in a *N*-dimensional space. Once images are indexed into the database using the extracted feature vectors, the retrieval of images is essentially the determination of similarity between the query image and the target images in database, which is essentially the determination of distance between the feature vectors representing the images. The desirable distance measure should reflect human perception. Various similarity measures [12,13,14] have been exploited in image retrieval.. In our implementation we have used Euclidean distance for similarity measurement. The distance d between two feature vector is given by:

$$d = \sqrt{\sum_{i=0}^{N} \left(f_q(i) - f_d(i) \right)^2} \qquad (3)$$

where

$f_q(i)$ is the ith feature vector of the query image

$f_d(i)$ is the ith feature vector of the database image

Experimental Results

In this section the retrieval effectiveness of the region based shape descriptor is studied We have implemented the medical image retrieval system using GFD descriptors in Java on Windows platform in Pentium Processor.

Test Database

We have created a medical image database of 10,000 images containing a large variety of differing images from CTs, MRIs, to radiographs. These images include various parts of the body like lung, heart, eye, ears, liver, bones etc. Most images are grey level images but there are several colored images as well. Figure 3 shows some image examples from the database. Our database images are converted from the DICOM format or other formats into JPEG. For real clinical studies, the use of DICOM images with the full grey level information is necessary. Twenty images from the database collection were chosen as query images for the evaluation of the system. They are from various anatomic regions, have varying difficulties and represent mostly grey scale but also a few queries with colors. Figure 4 gives the sample shot of the retrieval of a query image using GFD shape descriptor.

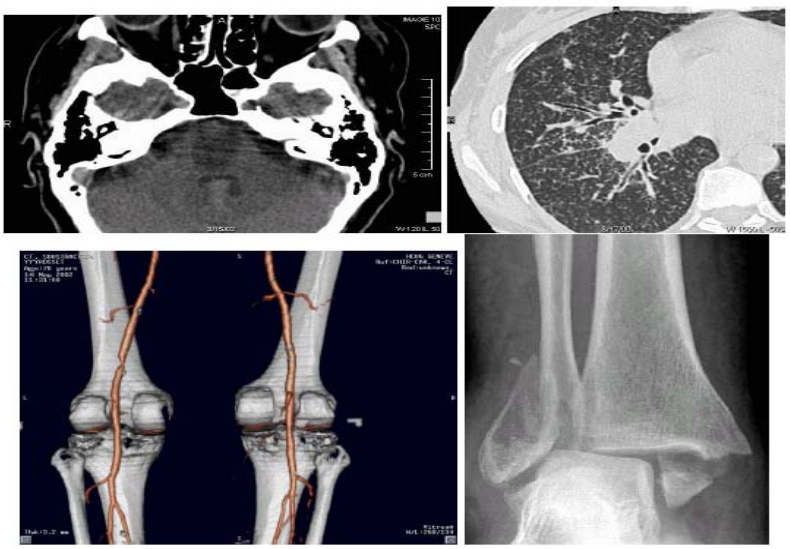


Figure 3: Sample images from the medical image database

Retrieval Performance

Precision and Recall [15] are the most widely used retrieval performance measurement in literature. It is based on categorical matching. In this method, dataset is converted to binary set according to relevance or irrelevance to the query based on subjective test. In the subjective test, each subject selects items relevant to the query from the dataset. Items selected for each query by more than the predefined number of subjects are considered relevant to the query, otherwise, they are treated as irrelevant. The precision and recall are then defined as

$$P = \frac{r}{n_1} = \frac{\text{number of relevant images}}{\text{number of retrieved images}}$$
$$R = \frac{r}{n_2} = \frac{\text{number of relevant images}}{\text{total number of relevant images in DB}} \quad (4)$$

Precision measures the retrieval accuracy while recall measures the ability of retrieving relevant items from the database. Precision and recall are inversely related, i.e., precision normally degenerates as recall increases.

Figure 4: Sample output of query image lung15.jpg Generic Fourier descriptor

Comparison on retrieval performance

Precision-recall is used for evaluation of retrieval effectiveness. For each query, the precision of the retrieval at each level of the recall is obtained. The final precision of retrieval using a shape descriptor is the average precision of all the query retrievals using the shape descriptor. Figure 5 gives the average precision and recall of 200 retrievals using GFD method.

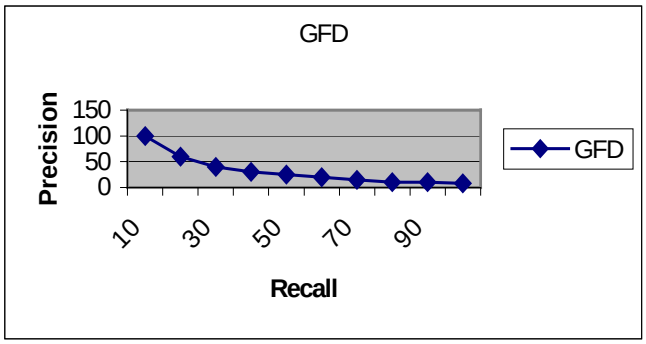


Figure 5: Precision and Recall graph of the GFD shape descriptor

We have conducted the experiments to check the rotation, scaling and translation invariant properties of the shape descriptor. From the obtained results we infer that Generic Fourier Descriptor has high retrieval performance.

Conclusion

In this paper, a medical image retrieval system have been developed using GFD as the shape descriptor. The retrieval performance of the descriptor was tested on the large medical image databases and quantified by the classical precision and recall measures. From the retrieval experiments, we have concluded that the Generic Fourier Descriptor have high retrieval performance for the medical images.

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