CHAPTER - 3

CONTENT BASED IMAGE RETRIEVAL SYSTEM FOR MEDICAL DATABASES (CBIR-MD) - LUCRATIVELY TESTED ON ENDOSCOPY, DENTAL AND SKULL IMAGES

In medical field, digital images are produced in ever increasing quantities and used for diagnostics and therapy. The swift expansion of digital medical images has enforced the requirement of efficient Content-based image retrieval system for retrieving medical images that are visually similar to query image. Such systems provide great assistance to doctors in clinical care and research. In this chapter, a Content Based Image Retrieval System for Medical Databases (CBIR-MD) based on various techniques like Fourier descriptor, Euclidean distance, Haar Wavelet transformation, Canberra distance is developed and its performance is analyzed on Endoscopy, Dental and Skull images.

3.1 INTRODUCTION

Content-based image retrieval (CBIR) is the application of computer vision techniques to the problem of digital image search in large databases. CBIR enables to retrieve the images from the databases [AWM2000] [VSM2010]. Medical images are usually fused, subject to high inconsistency and composed of different minor structures. So there is a necessity for feature extraction and classification of images for easy and efficient retrieval [BRA2011]. CBIR is an automatic retrieval of images generally based on some particular properties such as color composition, shape and texture [RPA2002] [WZH1998]. Every day large volumes of different types of medical
images such as dental, endoscopy, skull, MRI, ultrasound, radiology
are produced in various hospitals as well as in various medical centres [MES2011]. Medical image retrieval has many significant
applications especially in medical diagnosis, education and research fields. Medical image retrieval for diagnostic purposes is important
because the historical images of different patients in medical centres
have valuable information for the upcoming diagnosis with a system
which retrieves similar cases, make more accurate diagnosis and
decide on appropriate treatment. The main objective of this research
work is to retrieve the similar images matching the query image from
medical databases by using feature extraction and similarity
measurement techniques.

In picture archiving and communication system (PACS), image
information is retrieved by using limited text keyword in special
fields in the image header (e.g. patient identifier). Content-based
image retrieval (CBIR) has received significant attention in the
literature as a promising technique to facilitate improved image
management in PACS system [HMU2004] [TML2004]. The Image
Retrieval for Medical Applications (IRMA) project [TML2004]
[CTH2005] aims to provide visually rich image management through
CBIR techniques applied to medical images using intensity
distribution and texture measures taken globally over the entire
image.

This approach permits queries on a heterogeneous image
collection and helps in identifying images that are similar with
respect to global features e.g. all chest x-rays in the AP (Anterior-
Posterior) view. The IRMA system lacks the ability for finding
particular pathology that may be localized in particular regions
within the image. In contrast, the Spine Pathology and Image
Retrieval System (SPIRS) [SAN2004] [LRL2005] [GRT2006] provides
localized vertebral shape-based CBIR methods for pathologically
sensitive retrieval of digitized spine x-rays and associated person metadata. Image Map [EGM2002] is so far, the only existing medical image retrieval that considers how to handle multiple organs of interest and it is based on spatial similarity. Consequently, a problem caused by user subjectivity is likely to occur, and therefore, the retrieved image will represent an unexpected organ. ASSERT [CSH1999] (Automatic Search and Selection Engine with Retrieval Tools) is a content–based retrieval system focusing on the analysis of textures in high resolution Computed Tomography (CT) scan of the lung. In WebMIRS [LRL1998] system, the user manipulates GUI tools to create a query such as, “Search for all records for people over the age of 65 who reported chronic back pain. Return the age, race, sex and age at pain onset for these people.” In response, the system return values for these four fields of all matching records along with a display of the associated x-ray images. CervigramFinder system [ZXU2008] operates on a subset of the cervigram database. To use this system, the user defines a query by marking a region of interest on an image through GUI.

SPIRS-IRMA is a CBIR system based on the merits of two already existing systems (SPIRS & IRMA). So there is a need of absolute error free, efficient and automatic CBMIR system which can be really helpful in medical stream.

3.2 PROPOSED SYSTEM

In proposed system like other CBIR system, images are represented by appropriate feature vector in feature space. Such feature vector gives meaningful information of image properties. Fig. 3.1 reflects the working as well as milestone achieved after completion of each discrete process in proposed CBIR-MD system.
3.2.1 METRICS FOR FEATURE EXTRACTION

- FOURIER DESCRIPTORS

Fourier transform is used to generate the feature vectors based on the mean values of real and imaginary parts of complex numbers of polar coordinates in the frequency domain. Fourier Descriptors (shape based) can be used as a dominant feature for boundaries and object representation [QCH2004]. Consider a M point digital boundary, starting from an arbitrary point \((x_0, y_0)\) then \((x_1, y_1)\), ..., 
\((x_{M-1}, y_{M-1})\) can be generated. These coordinates can be represented in a complex form as:

\[ q(m) = x(m) + jy(m), \quad m = 0, 1, 2, \ldots, M - 1 \]

The Discrete Fourier Transform (DFT) of \(q(m)\) gives

\[ b(k) = \frac{1}{M} \sum_{m=0}^{M-1} q(m)e^{-j2\pi km/M} \quad k = 0, 1, 2, \ldots, M-1 \]

The complex coefficients \(b(k)\) are called Fourier descriptors of the boundary.

**HAAR WAVELET**

Haar Wavelets [JSW2011] are fastest to compute and simplest to implement. In addition user queries tend to have large constant-colored regions, which are well represented by this basis. The technical disadvantage of Haar Wavelet (HW) is that it is not continuous and therefore not differentiable.

In CBIR-MD, both Fourier Descriptor and Haar Wavelet are used for feature extraction.

### 3.2.2 METRICS FOR SIMILARITY COMPARISON

Distance metric is the main tool for retrieving similar images from large medical databases. In CBIR-MD, Euclidean distance [VSM2010] and Canberra distance [SCI2008] are used for the purpose of similarity comparison.

\[
ED = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (f_q(i) - f_{db}(i))^2}
\]

Where \(f_q(i)\) stands for \(i^{th}\) query image feature and \(f_{db}(i)\) for corresponding feature vector database. Here \(N\) refers to number of images in database.

\[
\text{Canberra Distance (CD)} = \frac{\sum_i |u_i - v_i|}{\sum_i |u_i| + |v_i|}
\]

Where \(u\) and \(v\) are both \(n\)-dimensional vectors.
3.2.3 RETRIEVAL PROCESS

The following steps are performed in the retrieval process:

**Step 1:** Input query medical image.

**Step 2:** Extract features by using Fourier Descriptor (FD) or Haar Wavelet (HW).

**Step 3:** Format/Collect the medical images from the medical databases at a point.

**Step 4:** Read medical images one by one.

**Step 5:** Extract features by either of the above mentioned techniques.

**Step 6:** Compare features of the query medical image with medical images from the database by Euclidean Distance (ED)/Canberra Distance (CD) technique.

**Step 7:** Store the result.

**Step 8:** Perform sorting of the result.

**Step 9:** Display the corresponding medical images.

3.3 EXPERIMENTAL STUDY

3.3.1 DATASET FOR THE EXPERIMENT

The functional code of proposed system is implemented using MATLAB 7.8 on an Intel Core 2 duo, 2 GHz window based laptop. The system is tested on three different dataset having 200 dental images, 1100 endoscopy images and 50 skull images respectively.

3.3.2 PERFORMANCE PARAMETERS

**Precision and Recall (P-R):** The images are retrieved and measured against P-R [MHE2004] as:

\[
P = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}}
\]

\[
R = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in the database}}
\]

where P is the ratio to measure accuracy and R is used to measure robustness.
3.3.3 EXPERIMENTS AND RESULTS

i) Subject Test on Endoscopy Images Dataset: The retrieval of images is observed for the database of 1100 Endoscopy images. The retrieval accuracy with FD/CD, FD/ED, HW/CD and HW/ED is observed and shown in Table 3.1.

Table 3.1 Precision-Recall Against Various Descriptors for Endoscopy Images

<table>
<thead>
<tr>
<th>Feature Extraction Technique</th>
<th>Distance Calculation Technique</th>
<th>Delay (Output) in seconds</th>
<th>Precision (%)</th>
<th>Recall (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD</td>
<td>CD</td>
<td>4-6</td>
<td>80</td>
<td>82</td>
</tr>
<tr>
<td>FD</td>
<td>ED</td>
<td>22-26</td>
<td>74.2</td>
<td>74.0</td>
</tr>
<tr>
<td>HW</td>
<td>CD</td>
<td>11-16</td>
<td>79.3</td>
<td>72</td>
</tr>
<tr>
<td>HW</td>
<td>ED</td>
<td>4-8</td>
<td>79.8</td>
<td>80</td>
</tr>
</tbody>
</table>

The results obtained from these descriptions can be seen through output screens of the developed system for any query image (represented by Fig. 3.2) in Fig. 3.3, Fig. 3.4, Fig. 3.5 and Fig. 3.6.

![Fig. 3.2 Query Image for Endoscopy Dataset](image_url)
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Fig. 3.3 Retrieved Images from Endoscopy Dataset for the Query using FD/CD

Fig. 3.4 Retrieved Images from Endoscopy Dataset for the Query using FD/ED

Fig. 3.5 Retrieved Images from Endoscopy Dataset for the Query using HW/CD
ii) Subject Test on Dental Images Dataset: The retrieval of images is observed for the database of 200 dental images. The retrieval accuracy with FD/CD, FD/ED, HW/CD and HW/ED is observed and shown in Table 3.2.

Table 3.2 Precision-Recall Against Various Descriptors for Dental Images

<table>
<thead>
<tr>
<th>Feature Extraction Technique</th>
<th>Distance Calculation Technique</th>
<th>Delay (Output in seconds)</th>
<th>Precision</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD</td>
<td>CD</td>
<td>4-6</td>
<td>74.6</td>
<td>72.2</td>
</tr>
<tr>
<td>FD</td>
<td>ED</td>
<td>22-26</td>
<td>70.1</td>
<td>69.8</td>
</tr>
<tr>
<td>HW</td>
<td>CD</td>
<td>11-16</td>
<td>73.1</td>
<td>70.2</td>
</tr>
<tr>
<td>HW</td>
<td>ED</td>
<td>4-8</td>
<td>71.2</td>
<td>69.2</td>
</tr>
</tbody>
</table>

The results obtained from these descriptors can be seen through output screens of the developed system for any query image (represented by Fig. 3.7) in Fig. 3.8, Fig. 3.9, Fig. 3.10 and Fig. 3.11.
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Fig. 3.7 Query Image for Dental Dataset

Fig. 3.8 Retrieved Images from Dental Dataset for the Query using FD/ED
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Fig. 3.9 Retrieved Images from Dental Dataset for the Query using FD/CD

Fig. 3.10 Retrieved Images from Dental Dataset for the Query using HW/CD
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iii) Subject Test on Skull Images Dataset: The retrieval of images is observed for the database of 50 Skull images. The retrieval accuracy with FD/CD, FD/ED, HW/CD and HW/ED is observed and shown in Table 3.3.

Table 3.3 Precision-Recall Against Various Descriptors for Skull Images

<table>
<thead>
<tr>
<th>Feature Extraction Technique</th>
<th>Distance Calculation Technique</th>
<th>Delay (Output) in seconds</th>
<th>Precision</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD</td>
<td>CD</td>
<td>4-6</td>
<td>75.6</td>
<td>72.3</td>
</tr>
<tr>
<td>FD</td>
<td>ED</td>
<td>22-26</td>
<td>70</td>
<td>68.2</td>
</tr>
<tr>
<td>HW</td>
<td>CD</td>
<td>11-16</td>
<td>73.2</td>
<td>70.7</td>
</tr>
<tr>
<td>HW</td>
<td>ED</td>
<td>4-8</td>
<td>74.1</td>
<td>72</td>
</tr>
</tbody>
</table>

The results obtained from these descriptors can be seen through output screens of the developed system for any query image (represented by Fig. 3.12) in Fig. 3.13, Fig. 3.14, Fig. 3.15 and Fig. 3.16.
Fig. 3.12 Query Image for Skull Dataset

Fig. 3.13 Retrieved Images from Skull Dataset for the Query using FD/CD

Fig. 3.14 Retrieved Images from Skull Dataset for the Query using FD/ED
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Fig. 3.15 Retrieved Images from Skull Dataset for the Query using HW/CD

Fig. 3.16 Retrieved Images from Skull Dataset for the Query using HW/ED
3.4 SUMMARY
A technique that effectively use most of the information from image is backbone of an efficient content-based image retrieval system for medical databases. In this chapter, an image retrieval system based on various techniques for feature extraction and similarity measurement is developed. The experiment is performed on three different datasets in order to measure the accuracy and robustness of the system. It has been observed from the experimental study that FD and CD combination gives better result in terms of delay, precision and recall. Future work may be carried out in the the field of image enhancement and there is a need for GUI based CBIR-MD for creating better user interface to interact and work efficiently with the system.