A Hybrid Image Retrieval System Based on an Experimental Analysis of Medical Images

Shikha Bhardwaj

Assistant Professor
Department of ECE
UIET Kurukshetra University
Kurukshetra, India.

***Abstract*- There are vast amount of images which are being available on the internet and the number of these images are being continuously increased due to the latest and advanced technological developments in the field of hand-held cameras and mobile phones. In order to retrieve, the desired images from a vast storehouse of images (internet), a system called as Content-based Image Retrieval (CBIR) is used where images can be obtained by the extraction of image features like color, texture, shape, edge, etc. In this paper, a hybrid image retrieval system based on texture and edge features have been developed using Local binary pattern (LBP) and Canny edge descriptor respectively. Then, an optimization technique, viz. Particle Swarm Optimization (PSO) has been applied on the results of the hybrid system. A medical database of 500 images has been used for the purpose of experimentation and Precision, Recall and f-score has been calculated successfully.**

***Index Terms*: Content-based Image Retrieval, Canny edge detector, Particle swarm optimization, Local binary pattern.**

I. INTRODUCTION

The text-based image retrieval was traced back in the late 1990s. A very frequent image retrieval system was to keyword annotate the images and use text-based database management system to retrieve the image. Text-based image retrieval [1] is based on manually adding annotations to display the images, or on collateral text that is inadvertently present with an image retrieval (Subtitles, captions, text adjacent). It applies traditional methods for retrieving text to annotations or descriptions of images [2]. CBIRS is regarded as the best way to retrieve an image. With the rapid growth of digitized image capturing devices and internet technology, it was found that the variety of digital image datasets have been created on the internet which are further being utilized in different fields or applications such as schooling, journalism, marketing, web, social media, medical imaging, entering etc. [3].

CBIR research and development (R&D) problems cover a variety of subjects, many of which are shared with mainstream image processing and retrieval of data. The basic working of an image retrieval system is depicted in Fig. 1. Firstly, the user has to submit the query in the form of an image and there are a large number of images present in the database, which is being utilized by the user. Then, the next stage is feature extraction stage which will be carried out in both the phases [4]. Then, after feature extraction, feature vectors are formed which have to be compared with the feature vector of query image and for this purpose, a matching stage is needed. In this stage, using a particular distance metric, matching is being done between the query image and database images and the image with the shortest distance is ranked as the top image. The user can retrieve N top images based on his choice.

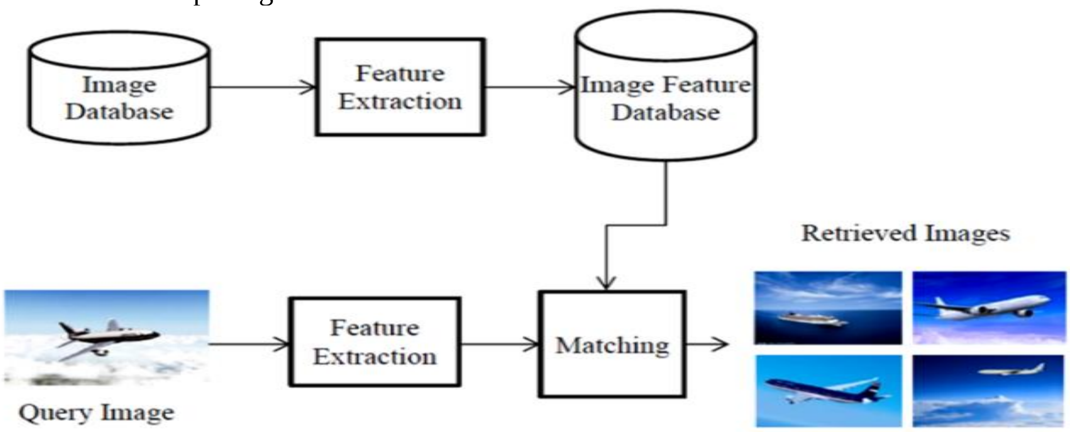

Fig. 1 Basic Image Retrieval System

The main highlights of this paper are:

- A detailed discussion on various CBIR systems has been presented in the related works.
- The development of a hybrid and optimized CBIR system by extracting texture and color features.
- Analysis of medical dataset consisting of 500 different images using various evaluation parameters.

The remaining organization of the paper is as follows: Section 2 highlights the related work done in context to CBIR system. Proposed Methodology has been presented in Section 3. In section 4, distance metrics and evaluation parameters have been given. Results and work done is presented in Section 5. The paper ends with a firm conclusion and future trends which are depicted in section 6.

II. RELATED STATE-OF-THE-ART WORK

In the past times, many techniques and algorithms have been used to develop variety of CBIR systems. A type of CBIR system has been developed by [5] which is based on improving alphanumeric pathology and histological sections which can further easily be scanned by pathologists as full photographic alphanumeric images. Computer-aided diagnosis (CAD) tool is utilized for this purpose.

Though CBIR system has many applications and it can be easily combined with many latest technologies like artificial intelligence (AI), Internet of things (IoT), machine learning (ML), Deep learning (DL) and many more. A combination of such an AI based image retrieval system has been proposed by [6]. Here, the author has utilized AI to extract the enhanced features of an image using VGG 16, which is a Convolutional neural network (CNN).

CBIR system can be developed as a single mode or as a hybrid mode. In a hybrid mode, more than two features can be extracted simultaneously. Such a hybrid system which is based on the extraction of color, texture and shape features has been developed by [7]. Color moment, Gray level co-occurrence matrix (GLCM) and region props have been utilized to extract color, texture and shape features respectively. Then, to add intelligence to the system, extreme learning machine (ELM) and relevance feedback (RF) have been used in combination.

Automated severity scoring of a disease can be easily done on medical images like COVID-19 images as in [8] has proposed a system where space time transformers has been effectively used for the detection of low, medium and high severity covid-19 lung images.

An IoT-based CBIR system has been proposed by [9] where two indexing based systems has been developed namely cluster-based deep belief network and supervised similarity based convolutional neural network. Also, an application based on IoT has been developed here.

CBIR system can be used in the area of medical imaging in various platforms like education, research and many other. Here, the authors have developed an interactive visual browser for retrieving medical images. These images can be retrieved independently or in combination with the meta-data associated with them [10].

Different algorithms and techniques can be used for the retrieval of medical images like wavelet transform, fourier transform, statistical methods, etc. A survey of different techniques has been presented by [11] for the retrieval of large medical dataset images. CNN has been effectively used in the field of medical images, based on the various usages of CNN as proposed by Toqa. Comparison of CNN with other algorithms have also been done in this paper [12].

III. PROPOSED METHODOLOGY

This section describes the proposed work which starts with a pre-processing phase called as Feature extraction. Every time a user enters a query image, an extraction for feature is executed for that image (Input image) and compared with all the feature vectors from database images Finally, the image with the most similar features is retrieved by the user, typically ordered by their similarity. In the proposed method, a hybrid CBIR system is formed by extracting texture and edge features of an image. LBP is used for texture extraction and Canny edge detector for extracting edge features. Lastly, an optimization algorithm called as Particle swarm optimization (PSO) has been applied successfully on the hybrid system to obtain optimized results as shown in Fig. 2.

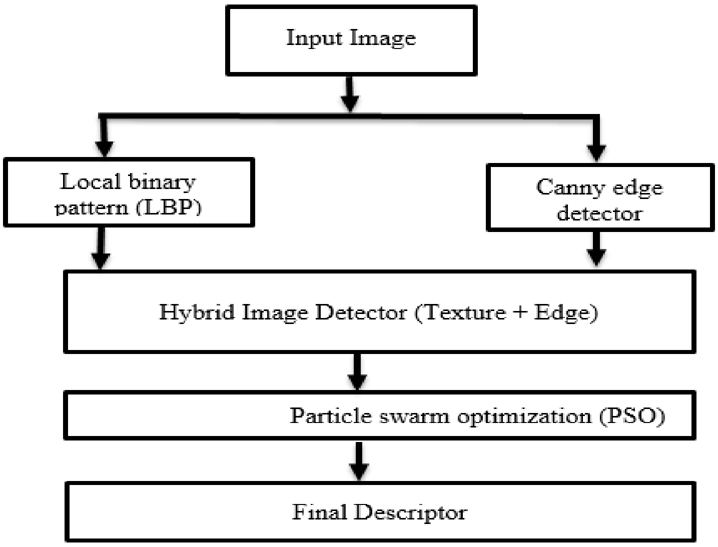

Fig.2 Block diagram of the Proposed system

Local binary pattern

LBP is a technique for texture extraction that is based on calculating the differences between neighboring pixels and dominant pixels [13]. A binary code is generated which can be measured as a binary pattern. The neighboring pixel converts to 1 if the value of the center pixel is larger than or equal to the threshold rate, and it converts to 0 if the value is smaller than the threshold [14]. Next, the histogram will be created to define the frequency of obtained patterns.

Canny edge detector

Canny edge detector is an edge detector which works on the following steps [15,16].

1. Finding edge with a low error rate.
2. The edge detector should identify the accuracy confined on the edge axis.
3. A specified edge of the image should be clear only once, and the image should not generate false edges.
4. Next is smoothing using linear filtering with a Gaussian filter followed by calculation of image gradient.
5. All points that are not at the extreme values should be supressed using non-maximum suppression followed by threshold calculation.

Particle Swarm Optimization (PSO)

PSO is based on imitating the simulations of group of bird's activities and finds best result in the probing space. Each particle in
probing space is measured as an applicant solution and finds the best results in home (local maxima) and world-wide (global maxima)
[17]. Particles move towards the best results to obtain near-global maxima and local maxima.

IV. DISTANCE METRICS AND EVALUATION PARAMETERS

Various distance metrics can be used for calculating the similarity between a query image and database images. Five distance metrics were utilized in the experimental work which are as follows:

Manhattan Distance

Manhattan distance is also called as city block distance. It is given by the following equation [18]:

$$D_C = \sum_{i=1}^{n} | I_i - D_i | \qquad (1)$$

Kullback-Leibler Divergence

KL-Div is just a slight change of formula for entropy. Relatively than just having likelihood distribution p*p*, a similar distribution q*q* is added given by [19]:

$$KL\ (p,q) = \sum i\ pi\ .\ log2\ \frac{(Pi)}{(qi)} \qquad (2)$$

Euclidean Distance:

Euclidean distance [20] metric is highly used in image retrieval since of its effectiveness and success.

$$D_E = \sqrt{\sum_{i=1}^{n} (|I_i - D_i)^2} \qquad (3)$$

Minkowski distance:

It is given by: $$D_M = [\sum_{i=1}^{n} (| I_i - D_i |)]^{\frac{1}{p}} \qquad (4)$$

Cosine distance

The cosine of dual non-zero trajectories can be calculated by using the Euclidean dot product method:

$$A.B = \|\boldsymbol{A}\|.\|\boldsymbol{B}\|\boldsymbol{cos}\theta \quad (5)$$

Specified two vector of features, *A* and *B*, the cosine comparison, cos (θ), is used for a dot product and scale.

Evaluation Parameters

To study the performance of image retrieval system, the primary evaluation parameters are:

1) Precision:

Precision denotes the proportion of predicted positive cases that are true real Positives [21].

$$\text{Precision: } P = \frac{Number\ of\ relevant\ image\ retrieval}{Total\ Number\ of\ images\ retrieved} \quad (6)$$

2) Recall:

Recall is the amount of real positive cases that are truly Predicted Positives.

$$\text{Recall: } R = \frac{Number\ of\ relevant\ image\ retrieval}{Total\ Number\ of\ relevant\ images\ in\ the\ database} \quad (7)$$

3) F-Measure:

F-measure effectively defines the true positives to the mean of predicted positive and
Real positives to perfect value.

$$\text{F- Measure: } \mathbf{F} = 2^* \frac{Recall \times Precision}{Recall + Precision} \quad (8)$$

V. RESULTS AND DISCUSSION

The tests were implemented on MEDICAL dataset consisting of 500 images with 5 categories where each category has 100 images each from Ankle, head, shoulder, pelvis and knee category.

Results

The proposed system has been checked on four different levels in terms of average precision. The average precision obtained at four different levels namely, texture-based, edge-based, hybrid and Hybrid+PSO is given in Table 1.

Table 1: Average Precision on texture, edge, Hybrid and Hybrid+PSO levels

Name of the Approach	**Average Precision (%)**
Texture-Based	94.34
Edge-Based	71.52
Hybrid	95.3
Hybrid + PSO	96.53

In this table, average precision has been calculated and here top 10 images are retrieved based on LBP which provides average precision of 94.34%. Canny edge produces average precision of 71.52%. Hybrid system has average precision of 95.3 and lastly the proposed PSO based hybrid system has average precision of 96.53%.

As the dataset has 5 categories, category-wise average precision has also been calculated. Category-wise average precision is given in Table 2 for all the four different levels.

Table 2: Average Precision (Category-wise)

Category Name	Texture Based	Edge Based	Hybrid System	Hybrid + PSO
Ankle	93.30	81.6	96.15	98.3
Head	92.0	78.25	86.05	88.5
Knee	93.95	74.95	99.6	98.9
Pelvis	95.85	68.25	98.45	99.2
Shoulder	96.6	54.55	96.25	97.75
Average Precision	94.34	71.52	95.3	96.53

In the above table, average precision has been calculated on all categories. Local Binary Pattern (LBP) technique results in 94.34% average precision, Canny Edge Detection results in 71.52% average precision and fusion of both texture and shape features results in 95.3% average precision. And Combination of both Hybrid and PSO is results in 96.53% average precision. Category-wise highest precision has been obtained for Pelvis category for hybrid+PSO combination.

Precision, Recall and F-measure have been successfully calculated on all the five categories. A bar-graph representation from all the categories for all the three parameters

has been given in Fig.3. In this Bar Graph, the average precision, recall and F-Measure has been calculated. The average precision is calculated on the retrieval of 20 images and is 96.53%. The average recall is 19.30% and average F-Measure is 32.17%.

Fitness function for the utilized PSO technique has been calculated and is shown in Fig.4

and is represented in the form of a graph. It is used in the form of 10 iteration of the loop. The first increase of the cost function is at -95 value and decrease at -96.5.

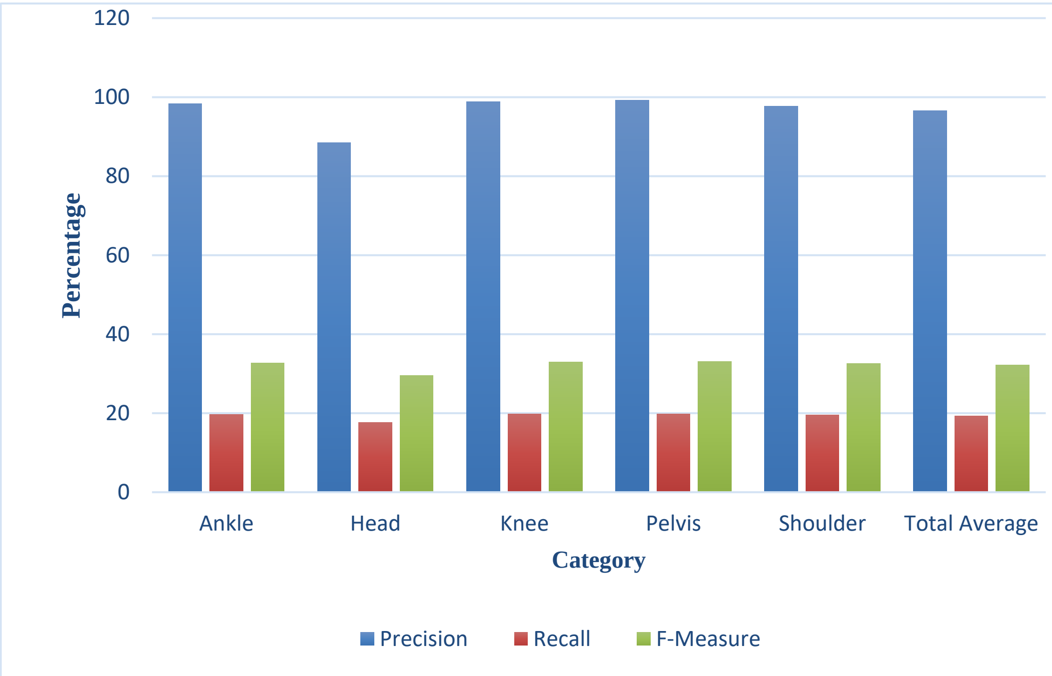

Fig.3 Precision, Recall and F-measure on 5 categories

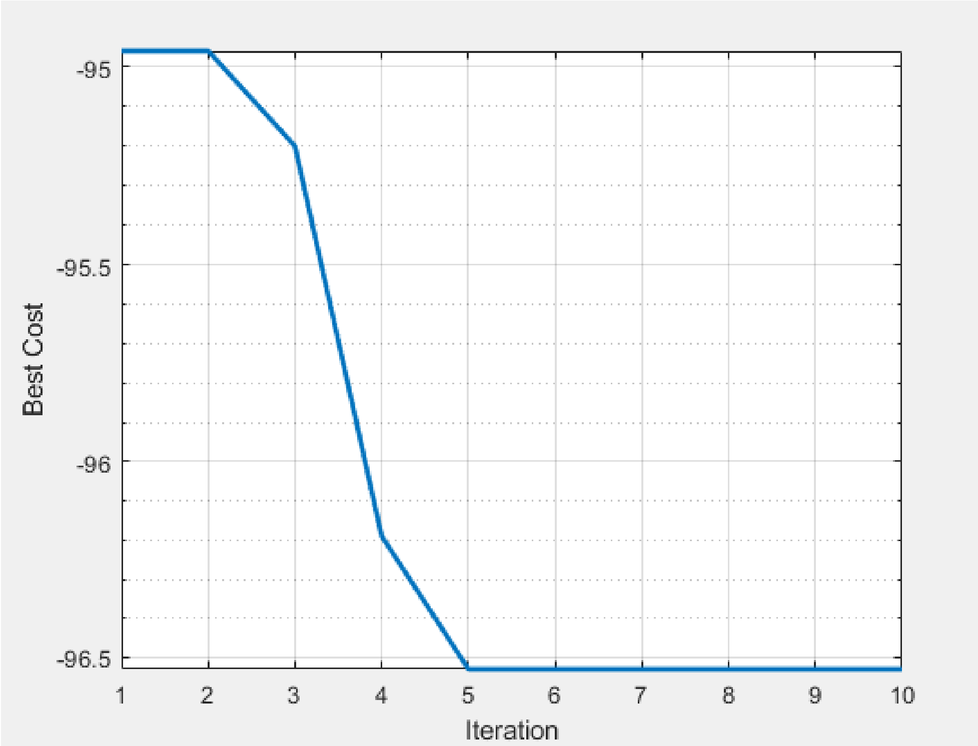

Fig.4 Fitness function

Average precision has been calculated using various distance metric techniques and is given in Table 3.

Table 3: Average precision on various distance metric techniques

Distance Metric	**Proposed System Precision (%)**
Manhattan	96.2
Kl-Div	92.2
Euclidean	88.8
Minkowski	78.4
Cosine	75.8

In this table, average precision on five distance matrices has been calculated. The peak average accuracy 96.2% is obtained by using Manhattan metric. The retrieved top 10 query image from all categories is also shown in Fig. 5 (a-e).

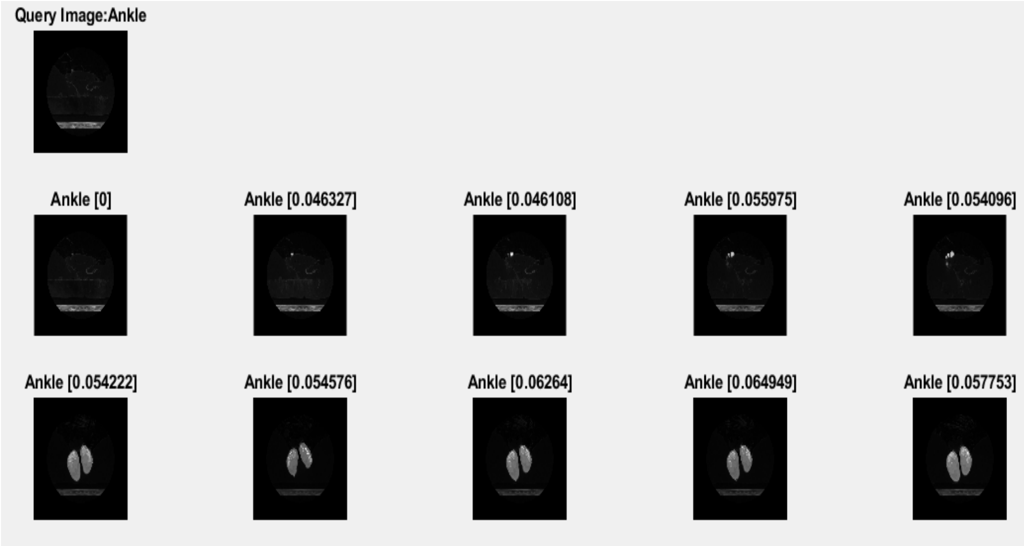

Fig. 5(a) Top 10 retrieved images from Ankle category

Fig. 5(b) Top 10 retrieved images from Pelvis category.

Fig. 5(c) Top 10 retrieved images from Knee category.

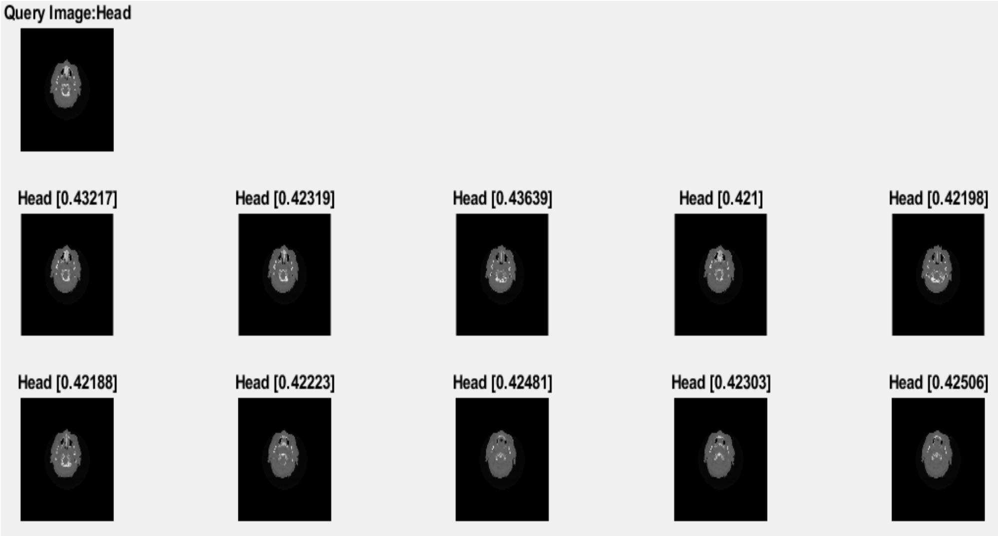

Fig. 5(d) Top 10 retrieved images from Head category

Fig. 5(e) Top 10 retrieved images from Shoulder category

VI. CONCLUSION AND FUTURE SCOPE

A novel hybrid CBIR system is proposed here which is based on the combination of texture and shape features. The texture feature are extracted by a local binary pattern (LBP) and shape feature are withdrawn by using Canny edge detector. Then the system uses Particle Swarm Optimization (PSO). A group of tests were executed to select the optimal terminology size which helps in finding the best retrieval results. All the experimentation has been done on Medical Database on Grey scale Images. The evaluation is done by calculating the average Precision, Recall, and F-Measure. The results depicts that our proposed system has superior results and is effective in image retrieval. Five distance metrics Manhattan distance, KL-divergence distance, Euclidean distance, Minkowski distance, and Cosine distance have been used. And amongst them, Manhattan distance offers the highest results.

In Future, more sophisticated and effective system can be designed which can use Deep learning algorithms for feature extraction in addition to optimization, and can add the smart technique of internet of things (IoT) with the help of which data or images can be retrieved in real-time.

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