A Systematic review on Content Based Medical Image Retrieval

Palwinder Kaur[1], Dr. Rajesh Kumar Singh[2]
[1]*Assistant Professor, Khalsa Institute of Management & Technology, Ludhiana*
[2]*Professor, SUS Institute of Computer Science, Tangori, Mohali, Punjab, India*

Abstract— Content based image retrieval (CBIR) has been one of the most active areas in computer science in the last decade as the number of digital images available keeps growing. One of the fields that may benefit more from CBIR is medicine, where the production of digital images is huge. Physicians can query large image databases to detect tumors and malformations in x-rays or magnetic resonance images based solely on the image content, without textual information that may have different interpretations. Extensive research has been done to develop methods to ensure that queries are increasingly faster and more effective but several problems related to the semantic meaning of the image content and to the retrieval efficiency in large databases are yet to be solved. In this paper, we are proposing the feature extraction and selection techniques such as Color auto-correlogram, Color moments, HSV histogram features, Stationary Wavelet transform (SWT) moments, Gabor wavelet transform, Binarized Statistical Image Features (BSIF). Further, the optimization techniques will apply to optimize the features such as PSO, firefly, cat swarm, Lion Optimization and Hybrid method to improve the precision and accuracy. Finally, classifier will be used to test the images using various methods such as DCNN, SVM, NN, Decision tree, CNN, K-Means, Bayesian and Stochastic Gradient Descent etc. to retrieve exact set of the images that will increase the performance of the proposed system and meets the user's requirement. The medical dataset will be used to training the testing purpose in CBIR. The proposed system also will be evaluated on the basis of various performance parameters.

Keywords— *DICOM; CT; PET; AES, DWT; Firefly; Accuracy;*

I. INTRODUCTION

With the advancement in internet and multimedia technologies, a huge amount of multimedia data in the form of audio, video and images has been used in many fields like medical treatment, satellite data, video and still images repositories, digital forensics and surveillance system. This has created an ongoing demand of systems that can store and retrieve multimedia data in an effective way. Many multimedia information storage and retrieval systems have been developed till now for catering these demands. The most common retrieval systems are Text Based Image Retrieval (TBIR) systems, where the search is based on automatic or manual annotation of images. A conventional TBIR searches the database for the similar text surrounding the image as given in the query string. The commonly used TBIR system is Google Images. The text based systems are fast as the string matching is computationally less time consuming process. However, it is sometimes difficult to express the whole visual content of images in words and TBIR may end up in producing irrelevant results. In addition annotation of images is not always correct and consumes a lot of time. For finding the alternative way of searching and overcoming the limitations imposed by TBIR systems more intuitive and user friendly content based image retrieval systems (CBIR) were developed. A CBIR system uses visual contents of the images described in the form of low level features like color, texture, shape and spatial locations to represent the images in the databases. The system retrieves similar images when an example image or sketch is presented as input to the system. Querying in this way eliminates the need of describing the visual content of images in words and is close to human perception of visual data. Some of the representative CBIR systems are Query by Image Content (QBIC).

A. CONTENT-BASED MEDICAL IMAGE RETRIEVAL (CBMIR)

The importance of medical image in healthcare is constantly growing, making healthcare more effective and patient friendly. With innovative imaging technology; diseases can be detected earlier with more precision, they can be treated more specific, less invasive and the beneficial result can be closely monitored. The number of digitally produced images are expanding strongly in various departments like radiology, endoscopy, dermatology, MRI, HRCT, X-rays, cardiology etc. The management and the access to these digital medical images repositories become increasingly complex. Most of the accesses to these systems are based on the patient identification or study characteristics like description, modality. Digital medical images can also be retrieved as text-based and content-based methods. So far, a variety of medical image retrieval systems have been developed using text-based or content-based methods or with a combination of these methods.

B. THE CONCEPT OF CONTENT-BASED RETRIEVAL

The idea behind content-based retrieval is to retrieve, from a database, media items (such as images, video and audio) that are relevant to a given query. Relevancy is judged based on the content of media items. Several steps are needed for

this. First, the features from the media items are extracted and their values and indices are saved in the database. Then the index structure is used to ideally filter out all irrelevant items by checking attributes with the user's query. Finally, attributes of the relevant items are compared according to some similarity measure to the attributes of the query and retrieved items are ranked in order of similarity. This chapter provides a short introduction to each of the steps mentioned above, which are also shown in Figure 1.1.

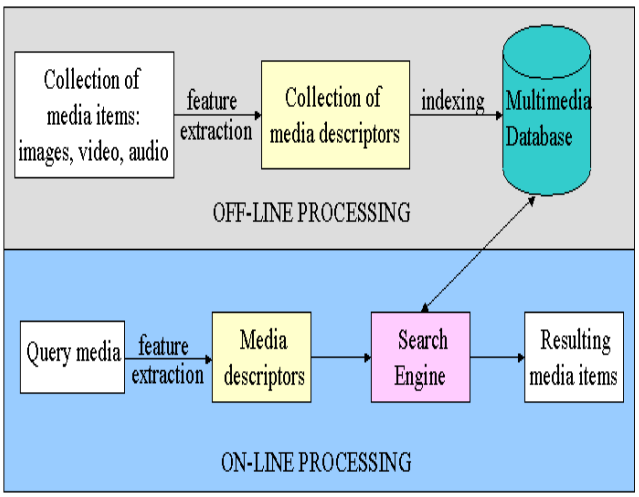

Fig.1: Block diagram of the content-based retrieval system

a) Feature Extraction

Feature extraction is one of the most important components in a content-based retrieval system. Since a human is usually judging the results of the query, extracted features should mimic the human visual perception as much as possible. In broad sense, features may be divided into low-level features (such as color, texture, shape, and spatial layout) and high-level semantics (such as concepts and keywords). Use of only low-level features might not always give satisfactory results, and therefore, high-level semantics should be added to improve the query whenever possible.

b) Indexing

When the number of images in the database is very large, there is a need for indexing visual information to avoid sequential scanning. Index structures ideally filter out all irrelevant images by checking image attributes with the user's query. Therefore, only relevant images have to be analyzed more carefully. Some examples of indexing methods used in content-based image retrieval are given in [3].

C. CHALLENGES IN CBMIR

The amount of visual data produced in medical field shows the importance of developing new and alternative access methods to complement text. CBIR techniques could be valuable to doctors in assessing medical images by identifying similar images in large archives that could assist with decision support. However, the incorporation of this technology to solve practical medical problems is a goal yet to be realized. Some of the open research issues to the use of CBIR in medicine are identified as:

- Due to the steadily increasing amount of medical image data, fast feature extracting and indexing techniques are needed that simultaneously narrow the gap between the numerical nature of features and the semantic meaning of images.
- The lack of interaction between medical and engineering experts, which is strongly related to usage and performance characteristics of CBIR systems and there is *Semantic gap* between low level features that are automatically extracted by machine and the high level concepts of human vision and image understanding.
- One of the challenges differentiating medical CBIR from general purpose multimedia applications is the granularity of classification; this granularity is closely related to the level of invariance that the CBIR system should guarantee.
- The combination of visual information retrieval with semantics and free text, the inclusion of the large amounts of medical data into the retrieval process and case-based retrieval, so as not to find similar images but rather similar cases. The shape-based descriptors are likely to be useful to fulfill the fine detail requirement of medical image retrieval. However, most of the current medical CBIR systems do not exploit the full potential of the shape information as they either use indirect correlates of the shape cue which are incapable of capturing the required classification granularity. The lack of evaluations of the retrieval quality of CBIR systems becomes apparent along with the unavailability of large image databases free of charge with defined query topics and standards.

II. CONCISED LITERATURE REVIEW

Content-based image retrieval (CBIR) for decades has been one of the most researched fields of computer vision. CBIR aims to search for images through analyzing their visual contents, and thus image representation is the crux of CBIR. In the past there has been a variety of proposed low-level feature descriptors for image representation, ranging from global features like color features, edge features, texture features, GIST and CENTRIST, and recent local feature representations, such as the bag-of-words (BoW) models using local feature descriptors (SIFT, SURF). Conventional CBIR approaches usually choose rigid distance functions on some extracted low-level features for multimedia similarity search, such as Euclidean distance or cosine similarity. However, the fixed rigid similarity distance function may not be always optimal to the complex visual image retrieval tasks due to the grand challenge of the semantic gap between low-level visual features extracted by computers and high-level human perceptions. The detailed literature reviews of CBIR are as follow:

Mutasem K. Alsmadi [1] proposed an effective CBIR system using MA to retrieve images from databases. Once the user inputted a query image, the proposed CBIR extracted image features like color signature, shape and texture color from the image. Then, using the MA based similarity measure; images that are relevant to the QI were retrieved efficiently. The conducted experiments based on the Corel image database indicate that the proposed MA algorithm has strong capability to discriminate color, shape and color texture features. Incorporating GD algorithm with the GA increased the quality of solution (weight) through increasing the fitness number, which helped in enhancing the process of exploitation during the searching process. Our proposed CBIR system was evaluated by different images query. The execution results presented the success of the proposed method in retrieving the similar images from the images database and outperformed the other CBIR systems in terms of average precision and recall rates. This can be represented from the precision and recall values calculated from the results of retrieval where the average precision and recall rates were 0.882 and 0.7002 respectively. In the future, filtering techniques will be employed to get more accurate results in the content based image retrieval system.

Adnan Qayyum et al. [2] proposed a deep learning based framework for con- tent based medical image retrieval by training a deep convolutional neural network for the classification task. Two strategies have been proposed for retrieval of medical images, one is by getting predic- tion about the class of query image by the trained network and then to search relevant images in that specific class. The second method is without incorporating the information about the class of the query image and therefore searching the whole database for relevant images. The proposed solution reduces the semantic gap by learning discriminative features directly from the images. The network was successfully trained for 24 classes of medical images with an average classification accuracy of 99.77%. The last three fully connected layers of the network have been used to ex- tract features for the retrieval task. Widely used metrics i.e., pre- cision and recall were used to test the performance of the pro- posed framework for medical image retrieval. The proposed sys- tem achieves a mean average precision of 0.69 for multimodal im- age data with class prediction.

Sk Mazharul Islam et al. [3] presents content-based image retrieval (CBIR) system with applications in one general purpose and two face image databases using two MPEG-7 image descriptors. The proposed method uses several sophisticated fuzzy-rough feature selection methods and combines the results of these methods to obtain a prominent feature subset for image representation for a particular query. Next, fuzzy-rough upper approximation of the target set (relevant list of images) with respect to the entire database that is represented by the prominent feature subset, is computed for retrieval and ranking. The information table on which every feature selection method works is small in size. Main reasons of performance boost of the proposed method are twofold. One is efficient feature subsets selection. The other reason is the fuzzy-indiscernibility relation based fuzzy-rough framework for computing upper-approximation which supports the approximate equality or similarity sense of CBIR. Fuzzy-rough upper approximation possibly adds more similar images in the relevant list from boundary region to expand the relevant list. The effectiveness of the proposed method is supported by the comparative results obtained from several single dimensionality reduction methods; several clustering based retrieval techniques and also tested for face image retrieval.

Wenbo Li et al.[4] a new medical image retrieval model is presented based on an iterative texture block coding tree. The corresponding methods for coarse-grained and fine grained similarity matching are also proposed. Moreover, a multi-level index structure is designed to enhance the retrieval efficiency. Experimental results show that, our methods are of high efficiency and appropriate tolerance on slight shifts, and achieve a relative better retrieval performance in comparison of other existing methods. Content-based medical image retrieval (CBMIR) has been widely studied for computer aided diagnosis. Accurate and comprehensive retrieval results are effective to facilitate diagnosis and treatment. Texture is one of the most important features used in CBMIR. Most of existing methods utilize the distances between matching point pairs for texture similarity measurement. However, the distance based similarity measurements are of low tolerance to slight texture shifts, which result in an excessive sensitivity. Furthermore, with the increase of the number of texture points, their time complexity is in explosive growth.

Deepanwita Datta et al.[5] proposed a graph-based keyphrase ex- traction model that captures the *relatedness* between words in terms of both mutual information and relevance feedback. Most of the existing works have stressed on bridging the *semantic gap* by using textual and visual features, either in combination or individually. The way these text and image features are combined determines the efficacy of any retrieval. For the purpose, they had adopted Fisher-LDA to adjudge the appropriate weights for each modality. This provides us with an intelligent decision-making process favoring the feature set to be infused into the final query. Our proposed algorithm is shown to supersede the previously mentioned key-phrase extraction algorithms for query expansion significantly. A rigorous set of experiments performed on Image CLEF-2011 Wikipedia Retrieval task dataset validates our claim that capturing the semantic relation between words through Mutual Information followed by expansion of a textual query using relevance feedback can simultaneously enhance both text and image retrieval.

Chaoran Cui et al. [6] have investigated the challenge of incorporating semantic information into CBIR, and addressed the problem by introducing the hybrid textual-visual relevance learning. To alleviate the sparsity and unreliability of tags, they performed tag completion to fill the missing tags as well as correct noisy tags of images. To

capture users' semantic cognition to images, they represented each image as a probability distribution over the permutations of tags. Textual relevance and visual relevance are effectively combined in a ranking aggregation way. Extensive experiments have been conducted on two benchmark datasets in comparison with the state-of-the-art methods.

III. PROBLEM STATEMENT

Content based image retrieval (CBIR) is a computer vision technique that gives a way for searching relevant images in large databases. This search is based on the image features like color, texture and shape or any other features being derived from the image itself. The performance of a CBIR system mainly depends on these selected features. The images are first represented in terms of features in a high dimensional feature space. Then, the similarity among images stored in the database and that of a query image is measured in the feature space by using a distance metric e.g., Euclidean distance. Hence, for CBIR systems, representation of image data in terms of features and selecting a similarity measure, are the most critical components. The goal of an image retrieval system is to retrieve a set of images from a collection of images such that this set meets the user's requirements. An image retrieval system provides the user with a way to access, browse and retrieve images efficiently from databases. These databases are used in a variety of domains including finger print identification, biodiversity information system, digital library, crime prevention, medical imaging, historical archives, etc. The available CBIR systems extract limited feature sets which confine the retrieval efficacy. In the research, we will use the standard feature extraction and selection techniques such as Color auto-correlogram, Color moments, HSV histogram features, Stationary Wavelet transform (SWT) moments, Gabor wavelet transform, Binarized Statistical Image Features (BSIF) for the feature extraction in the CBIR system. Then we will further apply the feature optimization techniques such as PSO, firefly, cat swarm and Lion Optimization method to improve the precision and accuracy. Afterwards classifier will be used to optimized image using various methods such as DCNN, SVM, NN, Decision tree, CNN, K-Means, Bayesian and Stochastic Gradient Descent etc. to retrieve exact set of the images that will increase the performance of the proposed system and meets the user's requirement. The proposed system will be evaluated on the various medical datasets (DICOM, CT and MRI) consisting of images of various modalities. To test the behavior of the proposed system will be evaluated with various performance parameters.

IV. RESEARCH OBJECTIVES

- To study and analyze the existing Content based image retrieval system.
- To apply the medical datasets such as DICOM, CT and MRI for training the images for image retrieval system.
- To extract and select the relevant features based on the feature extraction mechanism which further can be used to reduce the semantic gap by learning discriminative features directly from the images.
- To optimized the selected features of the trained distinct medical image from datasets based on latest and hybrid optimization algorithm to improve the accuracy and precision values.
- To classify the images based on the hybrid classification technique to improve the performance of the proposed system which meets the user expectation and increase the efficiency of the system.
- To analyze the behavior of the proposed system based on the various parameters such as Recall, Precision, F-Score and Sensitivity.

V. CONCLUSION

Content Based Image Retrieval (CBIR) is the process of searching and retrieving images from a database on the basis of features that are extracted from the image themselves. In this paper, we have presented the research proposal plan to achieve the higher accuracy in CBIR using various latest optimization techniques and classifiers. The research proposal has also pointed the focus on the research towards CBIR for medical images. For this purpose, the DICOM images will be used for image retrieval. The precision of image retrieval is dependent on the (1) feature extraction process, (2) feature similarity method. So, in order to achieve this, different methods has also discussed for feature extraction.

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