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An Agent-based CBIR System for Medical Images

Muhammad Usman Ghani Khan, Pervaiz Iqbal Khan, Khadim Hussain Asif, Abdul Nasir, Junaid Arshad and Sana Amanat
Department of CS&E, University of Engineering and Technology, Lahore
Corresponding author: usman.ghani@kics.edu.pk

Abstract
The growing number of image acquisition and storage systems in the digital world demand for the new retrieval methods. Most of the existing retrieval methods use textual information, which has been mainly entered manually for every image in the image collection. In order to access the images of interest, user gives textual input against which images are retrieved from the image collection. To overcome the issue, other approach which is generally considered is content-based image retrieval (CBIR). CBIR depends on the automatically extracted features for every image in the image collection as well as their storage and comparison upon a query. Therefore, feature extraction technique and their storage space are important aspects of CBIR. In this paper, we design and develop agent-based CBIR system for image retrieval and suggest the best feature extraction technique in terms of less storage space and more accurate search results. Although the proposed image retrieval technique can be used for any type image collection, our work focuses on the medical images.

Key words: Agent, CBIR, semantic, indexing, retrieval

1 Introduction
Digital image collections are growing at rapid pace due to the development in multimedia technology. According to Moore's law, processing power and storage space is no more an issue [1]. However, their efficient access mechanism is, still the area of high interest for the research community. Traditional image retrieval systems use the textual information to access image data. Images in the collections are annotated with the text by the human, describing the information about the image. For image retrieval, user provides textual query as an input which is matched against the annotations in the image collection and matched images are displayed. This technique sometime causes the garbage search results due to the human involvement in the annotation process because different humans have different interpretation for the same image. This also results into the mismatch of the annotation text and input query text and hence sometimes important information is missed. This problem has led to new research area known as the content-based image retrieval (CBIR) [2]. In CBIR, an example image is given as an input and the images having similar contents are returned.

A key challenge in implementing CBIR systems is that sometimes images data is noisy and complex [3]. For example, photographs of the same person at different locations. Despite the high visual similarity between two photographs, their representation is different at bit level. This fact requires similar search instead of exact search which usually works well for textual documents searching [3]. In CBIR systems, image features such as text, color, shape, boundary etc. which contain most important information about the image, are extracted for every image in the image collection and stored in the index database. When input image is given for search, its features are extracted, then compared with extracted features stored in the index database and images having features similar to the input image are returned. As CBIR highly depends upon the feature comparison, the selection of the appropriate image features is an important factor in determining the accuracy of search results.

In this paper, we present agent-based CBIR system and suggest the feature extraction technique which results into less storage space for index database and more accurate search results. Our architecture consists of three agents: 1) Indexer agent which extracts features for every image in the collection and builds index database for extracted features. 2) Searcher agent which compares the features of input image with image features in the index database and returns images having similar features. 3) Controller agent is responsible for taking input image, communicating with indexer agent and searcher agent and displaying the search results. Our approach can be used for any type of image collection. However, we use medical images as testing dataset. This can especially be helpful in disease diagnostics where patients images are available and images of new patient can be compared with them. For comparison purpose, we use different feature set such as Auto Color Correlogram, Color and Edge Directivity Descriptor (CEDD), Hashing CEDD, Color Histogram, Color Layout, Scalable Color, Fuzzy Color and Texture Histogram (FCTH), Full Document Builder, Joint Composite Descriptor (JCD) Document Builder, Joint Histogram, Jpeg Coefficient Histogram, Luminance Layout, Joint Histogram, Gabor, Opponent Histogram, Pyramid of Histograms of Oriented Gradients (PHOG) and Tamura and suggest which features work well for medical images on basis of size of created feature index database size and accuracy of search results.

Structure of the paper goes in the following order : Section 2. Literature Review highlights the existing work Section 3. System Overview describes the architecture and methodology we used in our work. Section 4. Experiments and Results discuss the experiments performed and their results and Section 5. Conclusion concludes the discussion.

2 Literature Review

Socrates Dimitriadis et al. [4] presented content-based image retrieval (CBIR) framework based on multi-agent architecture. Their framework consists of four components: 1) Software agents. 2) Image database. 3) Graphical User Interface (GUI). 4) Voting scheme. Software agents work in parallel to extract the features of images in the image database. This step is carried out at the time of image being imported to the database which reduces computational cost at real time. GUI is used by the user to input image against which search is performed. Result of the agents is combined on the basis of voting scheme chosen by the user. They used rank of the best match, the average rank of relevant image, the precision and the recall as performance metrics. They used Borda count and Weighted Voting methods for voting scheme and noted that sometimes Borda count method ignores relevant images.

John Moustakas et al. [5] developed two levels CBIR platform for brain magnetic resonance imaging (MRI) retrieval. Their work is based on human cognitive system. i.e. Pre-attentive stage and attentive stage. Pre-attentive level is used for the general similarity of images whereas attentive level is used for semantic based search. Their approach overcomes the “Semantic gap” problem in image search which is usually not handled by simple feature comparison approaches.

David Picard et al. [6] proposed a system to search images over the network. Their system is based on mobile agent technology which causes the reduction of network load because agent is very small in comparison to feature vector indexes. When user submits the input image, its similarity function is computed. An agent with the copy of computed similarity function is launched over the network. On each system over the network, agent indexing is performed over the images collection and results are displayed. User can label the result as relevant: 1 and irrelevant:-1 which is used in the future search results as a feedback to improve the results.

Pardeep Sing et al. [7] suggested a system CBIR based on the concept of soft computing agent whose retrieval engine is based on multi-agent architecture and abduction reasoning model. Knowledge base or image database of this retrieval engine is based on symbolic artificial intelligence which presents media patterns and image features as observation, belief an annotation. Assumption and evidence is provided to the retrieval engine where multi agents perform the search independently and generates inference as a result of input query. This system enhances the overall performance decision support systems.

.Mohammed Gheni Alwan et al. [8] proposed a paradigm that deals with the mapping of semantic concepts with low level features of image such as color; shapes etc. For that purpose, particular spatial relationship with respect to the conceptual objects is inattentive from images. This spatial relationship performs the leading role to map the semantic with the aid of multi-agents. To support the communication between agents, XML based semantic annotation is used where agents play a vital role to abstract the images to concepts by sharing their knowledge base with each other. An image contains multiple low level features like color, shapes which are mapped into its semantic concepts i.e. face which is comprised of lips, nose, eyes, topology of these concepts depicts the semantic of image which is utilized to index an image for retrieval purpose.

David Picard et al. [9] suggested a system that contains multiple image servers which further create access point for data retrieval; a static local agent is utilized to update the local database index. To make available these databases to the user a human, a machine interface is designed which is capable of receiving the user query image for retrieval purpose. When the user enters the query image, multiple mobile agents are moved to search those local agents dealing with image databases. When the appropriate local agent is selected, the searching criteria is provided to the local agent by the mobile agent to make search from particular database and return those images who fulfill the searching criteria of user. These images are processed by the human machine interface to present to the user. When user receives selected images from a pool of images received from mobile agents, a label is appended to that images which is further propagated to the computers and mobile agents of that database to update the level of pheromone of a pathway taken by that mobile agent; to optimize the paths by which relevant information can be assembled. These path ways help in finding the most relevant images according to the searching criteria. In order to get most relevant images against a query; learning approach is adopted such as support vector machine (SVM) classifier which behaved as a relevance function.

Robert Vermilyer [10] designed a system known as locating easy images (LIZY) which basically copes with dynamic user interface and query by sketching, in order to retrieve images with the help of various artificial intelligent processes. It basically deals with the two main issues, one of them is the user interface design and the second one is the performance evaluation. LIZY's user interface is comprised of basic three panes. One of them is used to draw hand insert images. Second pane consists of relevance feedback tool which is mostly used in CBIR systems. Prominent feature of its user interface is: it utilizes user interface agent with expert system and neural network which is previously not utilized in such type of system. The sketching tool is associated with user interface agent which takes help in order to refine the sketch and to enhance the quality of shape and its color by using expert system. User Interface Agent (UAI) is also linked with relevance feedback which is designed by using neural network to determine which should be display. To evaluate the performance, evaluation matrix is proposed which is based on f-measure matrix with accuracy constant 1.

David Picard et al. [11] propose a distributed CBIR system which is based on ant-like mobile agents. User input is received via an interface and the similarity function using Support Vector Machine (SVM) is calculated against user input which behaves as an indication to launch a new mobile agent over the network with a duplication of this similarity function. These agents communicate with the host of their particular network where the incoming agent is received and executed. Most relevant image is selected from a pool of labeled collection. These labeled images are provided to the user as a result of input query. Furthermore these agents crawl over the network to enhance their learning capabilities.

In this section, we presented the review of existing work. In CBIR, selection of feature set performs an important role for retrieving the accurate results. Up to the best of our knowledge, none of the existing work suggests features set which result into efficient and accurate image retrieval and less index database size. In this paper, we present the image feature set which creates index database with less size and results into more accurate. We use simple images as training dataset and medical images as testing dataset. Our experiments show that image feature CEDD creates less index database size and more accurate results for medical images.

3 System Overview

In this paper, we present content-based image retrieval (CBIR) based on multi-agent architecture. We extract features for every image in the collection and save them into index database. When user submits input image for search purpose, its features are extracted and compared with the features saved into index database. Top 30 matched images are returned to the user. We perform our experiments on medical images dataset and propose feature set that results into less index database size and more accurate search. Architecture of the proposed work is shown in Figure 1.

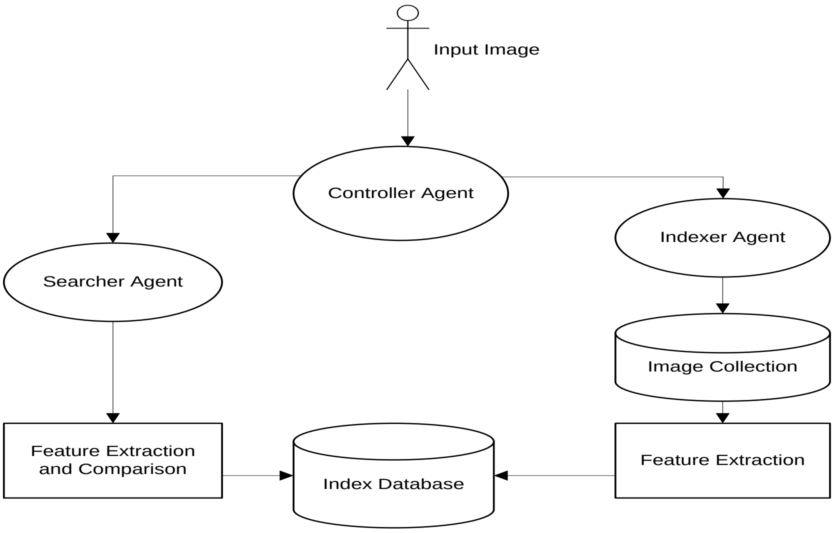

Fig. 1 CBIR architecture

Following are the three main components of CBIR system:

Indexer Agent: It waits for input message from the controller agent in order to perform some action. Once it receives message from the controller agent to extract image features, it crawls over the entire image collection, extracts image features for every image and saves them into index database. The saved features in the index database are used for comparison with the input image. We use different types of image features and save them into index database. Controller agent sends one of the Auto Color Correlogram, CEDD, Hashing CEDD, Color Histogram, Color Layout, Scalable Color, FCTH, Full Document Builder, JCD Document Builder, Joint Histogram, Jpeg Coefficient Histogram, Luminance Layout, Joint Histogram, Gabor, Opponent Histogram, PHOG and Tamura features to indexer agent as an input in order to extract features. Indexer agent extracts features and saves them into index data. Algorithm for indexer agent is shown in Figure 2(a).

Controller Agent: Controller agent is responsible for taking the input from the environment directly and displaying results. In our case, environment is the user interacting with CBIR system. On the basis of input message, it sends request to either indexer agent or searcher agent for further action. If the input message contains “index” in it, controller agent sends request to indexer agent. If input message contains input image, it forwards request to searcher which searches for the images similar to the input image. Once Searcher agent returns the matched images, it displays results back to the user. Algorithm for controller agent is shown in Figure 2(b).

```
1. m = RecieveMessage();
2. done= false;
3. t = GetFeatureType();
4. while (!done && m == "index") do
5.        get next image from collection
c;
6.     f= ExractFeatures(t,c);
7.      SavetoIndexDB(f);
```

Fig. 2(a) Indexer agent algorithm

```
1. m = RecieveMessage();
2. t = GetFeatureType();
3. i = RecieveInputImage();
4. if (m == "index")
5.  r = SendMessage(IndexerAgent, "index", t);
6. else if ( m == "search")
7.  r = SendMessage(SearcherAgent, "search",
t, i);
```

Fig. 2(b) Controller agent algorithm

Searcher Agent: It takes image as an input from the controller agent,

extracts its features and searches for the images the similar features from the indexed database. Once done, it returns top 30 images to the controller agent with most similar on the top. Algorithm for searcher agent is shown in Figure 2(c).

```
1. i = RecieveInputImage();
2. m = RecieveMessage();
3. done = false;
4. t = GetFeatureType();
5. e = ExractFeatures(t,i);
6. while (!done && m == "search") do
7.      get next image im from Index DB ;
8.      matched= comapreFeatures(im,
e);
9.      if (matched)
10.          mlist = AddtoMatchedList();
11.  end while
12. return mlist;
```

Fig. 2(c) Searcher agent algorithm

4 Experiments and Results

First, we use color images dataset that contained images of different classes. e.g. human, buses, animals, beach scenes. etc. We created image index database using different image feature sets. Then, we performed our experiments on medical images by selecting subset of image features used in the color images dataset. The criteria used for selecting subset of features was the features set that produced minimum index database size and returned more relevant image results on search. Our color images dataset consisted of a size of 28 MB. Size of index database created by each feature is given in Table 1.

Features	**Index Size (KB)**
Auto Color Correlogram	356
CEDD	100
Color Histogram	132
Color Layout	88
Edge Histogram	100
FCTH	88
Full Document Builder	1341
Gabbor	296
Hashing CEDD	720
JCD Document Builder	112
Joint Histogram	324
Jpeg Coefficient Histogram	608
Luminance Layout	104
Opponent Histogram	92
PHOG	348
Scalable Color	184
Tamura	124

Table 1. Index database size for colored images

As Table 1. Shows, CEDD, Color Histogram, Color Layout, Edge Histogram, FCTH, JCD, Luminance Layout, Opponent Histogram, Scalable Color and Tamura features produced relatively small index database. So we performed our image retrieval experiments using these features. Our search experiments showed that although, Color Histogram, Color Layout, FCTH, Luminance Layout and Scalable Color features created small index database, sometimes, they retrieved irrelevant images as they use color features of the image. Also, as medical images are black and white, these features are not useful for their retrieval. Therefore, the candidate feature set left for medical images were CEDD, Edge Histogram, JCD, Opponent Histogram and Tamura.

Further, we performed experiments on medical images dataset which consisted of brain MRI, Heart X-Ray, Chest X-Ray and other parts of body images. Total size of dataset was 1.2 MB. We created index database for it using CEDD, Edge Histogram, JCD, Opponent Histogram and Tamura features. Table 2 gives the detail of index database size for every feature set. After creating index database, we gave different images as input and noted that Tamura and Edge Histogram features resulted not only in large index database size but also in garbage search results. Although CEDD, JCD and Opponent Histogram produced the index database with the same size, CEDD feature produced the more accurate results as compared to the other two features. Figure 3(a) depicts the image used as an input while Figure 3(b) displays the search results against it.

Features	Index Size (KB)
CEDD	32
Edge Histogram	36
JCD Document Builder	32
Opponent Histogram	32
Tamura	44

Table 2. Index database size for medical images

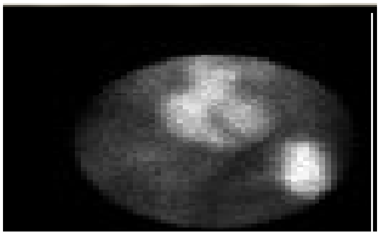

Figure 3(a). Input Image

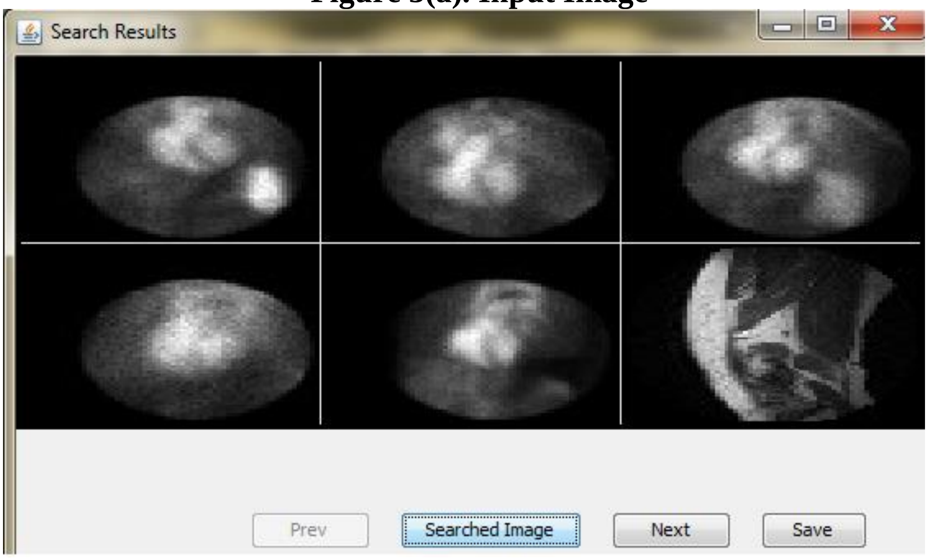

Figure 3(b). Search Results

5 Conclusion

In this paper, we proposed agent-based CBIR system for image retrieval and suggested the image features which return more accurate search results and create small index database. We performed our experiment on colored images dataset first and then on medical images. Our evaluation criteria for feature set was small index database size and high accuracy of results. We found that CEDD feature resulted into small index database size and high accuracy for both colored images as well as medical images.

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