IOSR Journal of VLSI and Signal Processing (IOSR-JVSP)
Volume 6, Issue 3, Ver. III (May. - Jun. 2016), PP 42-47
e-ISSN: 2319 – 4200, p-ISSN No. : 2319 – 4197
www.iosrjournals.org

Content Based Image Retrieval System Implementation through Neural Network

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Abstract: *Most of the existing content based image retrieval techniques use the features like color, texture and shape etc. which are extracted from the images. These techniques perform reasonably well, but the accuracy and efficiency using these methods is not very good. Therefore, the paper investigates different methods which can be used to get a satisfactory result, good performance and good response time. In this paper, the Content Based Image Retrieval is carried out by extracting the prominent features from the image and retrieval of images from database using neural network. Neural networks are used in retrieval of images from the database. The extracted salient features are used as the basis for a similarity check between the query image and images in the database, after processing the data with neural network. The Neural network recognizes to which category the query image belongs. The matching or similar images can then be retrieved from that category. The CBIR system was implemented through the MATLAB platform and the simulations were tested for various test images. The accuracy and retrieval performance of the system was improved as a result of using the salient features. This system can be used in variety of fields or applications, which consists of a large image collection or database.*

Keywords: *CBIR, Neural network, Fundus images, image retrieval, feature extraction.*

I. Introduction

In the past decade, more and more information has been published in computer readable formats. In the meanwhile, much of the information in old books and newspapers has been digitized and made computer readable. Big archives of films, music, images, satellite pictures, books, newspapers, and magazines have been made accessible for computer users. Internet makes it possible for the human to access this huge amount of information. The greatest challenge of the World Wide Web is that the more information available about a given topic, the more difficult it is to locate accurate and relevant information. Most users know what information they need, but are unsure where to find it. Search engines can facilitate the ability of users to locate such relevant information.

Especially, considering images, looking for a specific image over the vast expanse of internet is difficult. Every image represents certain attributes like color, texture, shape etc. There are used to search an image from database collection. Basically, each image has a "region of interest", it is most important part of the image, and defines the image. Taking for example an advertisement board, it has a main attracting object or feature which catches our attention. These attracting objects are called salient or prominent objects or main feature in the image. The salient or prominent object is usually the most outstanding and interesting part of the image. These features are useful for analysis and understating of the images.

In the digital age, virtually all of human has relationship to all fields including commerce, government, academics, hospitals, crime prevention, surveillance, engineering, architecture, journalism, fashion and graphic design, and historical research. These fields use images for efficient services. A large collection of images is referred to as image database. An image database is a system where image data are integrated and stored. Image data include the raw images and information extracted from images by image analysis.

Similarly, in the wide digital media network, there is a lot of information available in form of data, video, images etc. In a survey, a million images are uploaded to the internet every minute. Now that if we want to retrieve a particular or related image of our interest, it would be a herculean task. Hence there is a need to design retrieval system which is both quick and efficient in retrieving the images from an image database having collection of varied images of different categories, example: flower, aircraft, face, car etc.

In the proposed system, a particular image of our interest is given in as an input query image, the system should extract salient features from the image and the system must also extract features of all the images

in database. Next, the system must compare the features of query image with the features of each and every image in database and retrieve the intended image, if present or the similar images efficiently from the database [1][2].

II. Need Of Content Based Image Retrieval System

It has been noticed that the digital media is developing day by day, and the information is increasing accordingly, taking into consideration only the images. There is rapid increase in the images uploaded to internet, looking for specific images in web or otherwise in a collection images is very cumbersome job. Hence there is a need for content based image retrieval system. Many methods of image retrieval are present, but these methods have their own flaws. Consider the text or semantic method, if we use this method to retrieve image, say for e.g.: "find pictures of a jaguar", it may not always retrieve the jaguar we are looking for, it might retrieve image of the animal jaguar or the car jaguar. So the semantic method is not very ideal method for precise image retrieval. Similarly, if we consider color histogram method of image retrieval, if we try to retrieve yellow color rose, we might get yellow colored fruit as result. Considering the system which uses local features, this method does not represent the properties of the entire region of interest. Hence there is a need to develop an accurate image retrieving technique, based on the query.

The content of the image is used for the retrieval of the images from a collection. The content is accurate portrayer of the image. The features of the images like color, texture, shape, size etc. can be used as the content of the images for analysis. And using this content in process of content based image retrieval seems to be a lot more optimistic and accurate method. One advantage is, it is not semantically related to image but spatially related to image, hence realizing this system satisfies the need for the Content Based Image Retrieval.

Easy access to the required information is basic necessity in any system; the information is digital system is usually image, data or video. This information must be returned with accuracy. Visual information is the most easily perceived form of information by humans. As we know there is speedy growth in the amount of images in the web and there is a requirement for easy, fast and efficient accessibility of the digital images and this motivates research into image retrieval system.

Image retrieval can be based on the method using metadata or content. Metadata method of image retrieval is performed using the associated metadata such as index, tags, keywords and text. An image retrieval system can be developed using the metadata, but metadata based image retrieval may suffer from several critical problems including lack of appropriate metadata associated with images and the limitation of keywords to express the visual content [3].

These problems of metadata based image retrieval inspire the research of CBIR. CBIR aims to search images using the content of images which are usually specified by the visual features such as colour, texture and shape. The visual features that are extracted from the images are always consistent to the actual content of the images. Comparing this to the metadata search which can retrieve the images whose tags and index are similar but the images are named different due to the perception of having different users and also the creation of the semantic gap, creates ambiguity that can lead to retrieval of wrong images from the database [4].

Image retrieval plays an important role in situations which require immediate retrieval of specific images of interest [8]. The scope of this paper can be defined as development of a CBIR system that includes creating a database, extracting the features of the images and retrieval of images by training and testing the neural network for the database images and query images respectively. The salient feature extraction can be useful in areas of machine vision, face detection, medical imaging, automatic refocusing, object image search, etc.

III. Existing CBIR Systems

Over the years, many CBIR systems have been developed. Authors Venters et.al [5] identify 74 CBIR systems. Three CBIR systems i.e. ImageFinder, IMatch and QBIC are tested using smaller databases. Mueller et.al [6] has reviewed the different CBIR systems for medical applications. IBM's QBIC (Query By Image Content) is one of the well-known CBIR systems. The CBIR engine used in QBIC has been used for searching archives of famous art at the Hermitage website. Virage is one of the CBIR systems that find its applications in number plate recognition, face recognition and intelligent scene analysis. IMatch is a commercial image management system containing CBIR functionality. Along with the traditional database based retrieval, it also has functionality for retrieving through sketching an image instead of providing a query image.

There are a number of free CBIR systems. Octagon is one of the simple CBIR systems that use the Java software for CBIR. The program allows retrieval based on the image's visual content specifically the colour and texture of the image. Initially an image database is created, after which the jpeg images can be imported into the database. Once the database is established, the user can choose an image as a query image and the system returns a set of images most similar to the query image. It uses simple relevance feedback functionality where the user can indicate if the returned images are relevant, neutral or not relevant to the query.

Another free CBIR system is the Emir described in Lux. In Emir, it is possible to search for similar images based on colour layout, scalable colour and edge histograms. It also has additional functionality for the image annotation in the Caliph software. Two open CBIR frameworks which are available are GIFT and Windsurf. GIFT is an acronym for GNU Image Finding Tool and allows for query by image example and has functionality for relevance feedback.

Windsurf is an acronym for Wavelet based INDexing images using Region Fragmentation. It relies on the region based approach to implement CBIR. The Photoshop Elements is one of the recent additions in the CBIR system family. Its Auto-analyzer evaluates and identifies the interesting and important aspects of an image. The analyzer automatically searches the image collection and assigns a tag based on qualities such as lighting, focus and contrast. It also has a key feature of 'people recognition', which tags images that contain faces. The program basically learns the identity of faces frequently captured in the images and makes suggestions about who is in each photo based on user notes made during the import. Google image search is another popular system which is a feature in the Google search engine by 'Search by Image'. It is optimized to work well for content that is reasonably well described on the web and hence will most likely give more relevant results for famous landmarks or paintings than for more personal images. It uses computer vision techniques to match the query image to other images in the Google Images index and additional image collections. From those matches, the algorithm tries to generate an accurate 'best guess' text description of the query image, as well as to find other images that have the same content as the query image. The search results page can show results for the generated text description as well as related images.

IV. Feature Extraction And Retrieval Of Images

Image collection can be enormous in size containing a large database of images. In order to retrieve a specific image, a retrieval technique has to be implemented. The retrieval of an image requires utilizing the features of the images. There are different methods to extract the salient features and retrieve the exact image or similar images from the database.

The conventional methods include retrieving the image using only index, keywords, tags, low level features, regional level features, wavelet based features but using these methods have certain disadvantages like non-availability of human categorizer for text annotation, challenges in annotating very large databases, accuracy of retrieval, misrepresentation of image, mismatched image, need for post-processing, extraction of only local features and not regional features and vice versa. Hence a system needs to be developed which extracts the features which are balanced and overcome the challenges mentioned above.

Although few methods for CBIR have been developed in the past, like the images are retrieved based on text methods, where a descriptive keyword is assigned by a human categorizer or a person in general and images are retrieved based on the query text. But the descriptive keywords differ from one human being to another, because the perspective of each person differs. There also exists other retrieval systems based on primary attributes like colour, texture, histogram etc. where the images are compared using any one of the feature mentioned but these methods are prone to challenges mentioned above.

Hence a robust and efficient image feature extraction and retrieval techniques should be developed which is less prone to error and has a good response time.

In this paper, two areas are considered. The feature extraction and retrieval of the images using neural network. The problem statement can be defined as, a system is to be developed that accepts any image of user's interest as a query image and compare the image with the database and retrieve the exact matching if found or retrieve images of similar category to the query image. A solution to the problem statement is development of a system that accepts any image as query image and retrieves images by comparing or matching images from the database using certain features of the image. These features are extracted from the method of salient feature extraction using the saliency maps.

After the features extracted, a methodology is required to compute the variations and similarities in image which is done using the neural network. First the database images are fed as input into neural network and output of the neural network is saved and with the output of the neural network and compare the trained neural network with respect to the features of input query image. Finally with the output of the neural network after testing, the matching image or the images of similar category can be extracted from the database. The system should satisfy few requirements like accuracy, speed and efficiency.

V. Implementation Of The CBIR Neural Network

The design requirements and their corresponding implementations are discussed in this chapter.

1. *Extracting* Image Features

The proposed system should be able to extract the data i.e. features from the image. This step involves processing of complex image processing algorithms and methodologies which are needed to get an accurate result. These features are also utilized as data to compare the data from the image databases.

2. Training of the Neural Network

The system should be able to train the multi-layer neural network. Prior to the same, the system extracts features from all the images in the database and save them for the training of the neural network. The training of the neural network means initially a large dataset and rules pertaining to the dataset is fed to the neural network. Neural network is the model which learns statistically, and is inspired by the 'neuron' in the brain which forms a network to communicate. This network is essential as it is required for calculations of various functions.

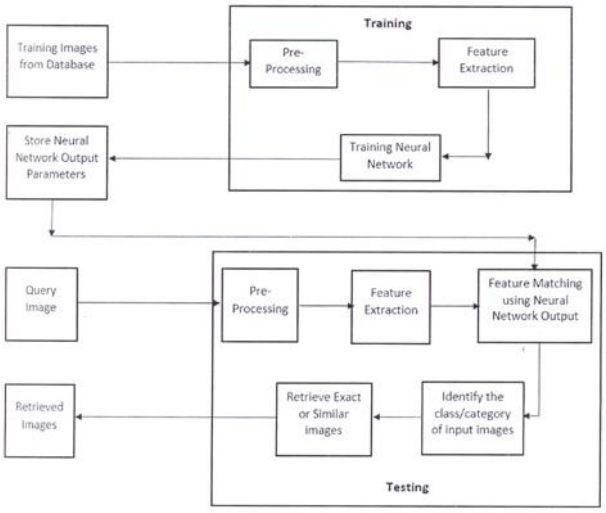

Figure 5.1: Block Diagram of the Proposed System

A neural network comprises of adaptive weights and these numerical parameters are tuned by learning algorithm itself. The adaptive weights are the link between the nodes of input, hidden and output layers.

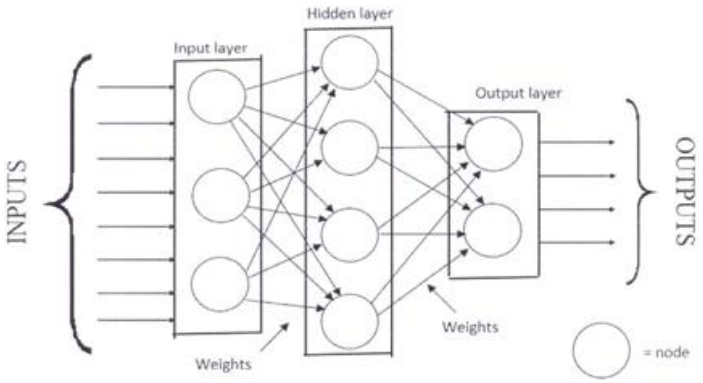

Figure 5.2: Schematic of the Neural Network

The above figure indicates three layers i.e. input layer, hidden layer and output layer. The input layer is the layer which accepts the input parameters, the hidden layer is the layer wherein the adaptive weights and input parameter are processed and the output layer displays the processed output of the hidden layer and the adaptive weights.

The training is the first step in neural network implementation. Training includes uploading a large dataset and the corresponding rules about the data relationship. The images from the dataset are read into a matrix and they are fed as inputs to the neural network. This is followed by the self-learning algorithm which trains the neural network. The images are classified based on their characteristics into different categories; for example the images of flowers are in category 1, the fundus images [7] are covered under category 2 and so on. The neural network acts as a classifier which gives the output such as to pint out to which class the image belongs to in the database. The multi-layer feed forward back propagation type of neural network (FFBPNN) is used. The neural network functions both in forward as well as backward direction. In the forward direction, it processes the input data and in the backward direction it propagates the error after the gradient descent which is used in the implementation. The output of the neural network is given in (1) wherein 'b' is the bias, 'W' is the weight matrix $[W_{1,1}, W_{1,2}, \ldots W_{1,r}]$ and 'p' is the weighted input vector $[p_1, p_2, \ldots, p_r]^T$.

$$a = f(W p + b) \qquad (1)$$

The above equation indicates that the input data are uploaded to the neural network from the input layer and the hidden layer performs its processing. The output layer gives the computed result, the self-learning property is realized using the gradient descent back propagation (indicated as TRAINGD), Levenberg – Marquardt (indicated as TRAINLM) back propagation and resilient back propagation (indicated as TRAINRP).

TRAINLM is a slow training method but reduces memory requirements. TRAINRP is slower than TRAINLM but it has better memory efficiency than TRAINLM. TRAINGD is a network training function that updates weight and bias values according to the gradient descent. Its error function e_k is defined in (2) wherein 'd_k' indicates the desired output and 'e_k' indicates the actual output.

$$e_k = d_k – y_k \qquad (2)$$

The gradient descent is thereby given in (3) wherein 'x_k' is the weighted sum of input values to node 'k'. After the neural network is trained, the output of the neural network is stored and is used to test the neural network.

$$\delta_k = (\delta y_k / \delta x_k) \text{ X } e_k \qquad (3)$$

3. Retrieval of the Image

Once the neural network is trained, the system should accept an image as query and it should extract the features of the input image and compare it with the trained neural network i.e. the testing phase of the neural network and thereby the accurate match of the image should be retrieved. From Fig. 5.1, it can be noticed that two important blocks are the Preprocessing block and the Feature extraction block. The preprocessing block consists of functionalities such as smoothing, close (dilates + erodes), Max filtering, Min filtering, Mean filtering, and open (erode + dilate). It also has the resizing functionality and changing color models from one form to other. The feature extraction block is the most memory intensive part of the implementation.

VI. Results And Conclusion

The images in the database classified category-wise and defined as flower images, fundus images [9] and airplane images are considered. The input image is considered as the query image which is loaded to the system. Once the algorithm is executed, the images matching to the query image are retrieved from the database. The neural network is trained with the data of the extracted features of the images present in the database. The data is processed and saved. The neural network is then tested using the query image against the saved data from the training of the neural network and thereby retrieving the exact matching image or similar images from the database. The testing parameters used in implementation and their corresponding results are shown in Table 6.1.

Table 6.1: Training Parameter verification

Training Parameters	Values
Humber of Neurons in Hidden layer	20
Maximum Epochs	500
Network training function	TRAINGD
Expected MSE	0.0001

The training, testing and validation plot for the Epoch vs. Minimum Squared Error (MSE) is as shown in Fig. 6.1 and from the figure, it can be noticed that at epoch 33, the MSE is 0.36556.

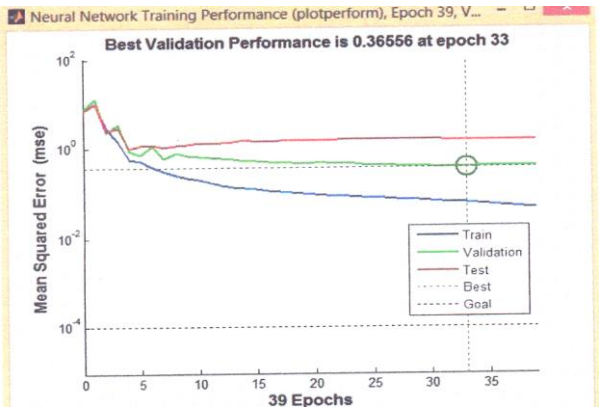

Figure 6.1: Performance

Fig.6.2 indicates the training states. It can be concluded from the figure that the gradient descent for the MSE decreases as the number of iterations increases thereby increasing the number of validations.

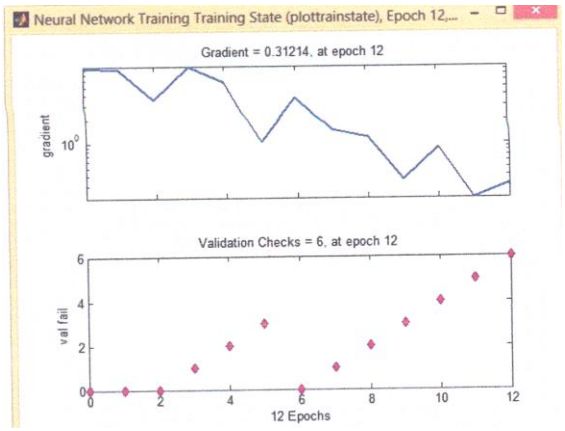

Figure 6.2: Training parameter verification

Fig. 6.3 indicates the regression analysis that the maximum likelihood data (indicated as small circles) is the one that minimizes MSE. The slope of the line is the correlation between the output and target data. It can be concluded from this figure that the data of target matrix fits with regression of 0.66887 during training, during testing it is 0.80381, during validation it is 0.70796 and overall it is 0.69814.

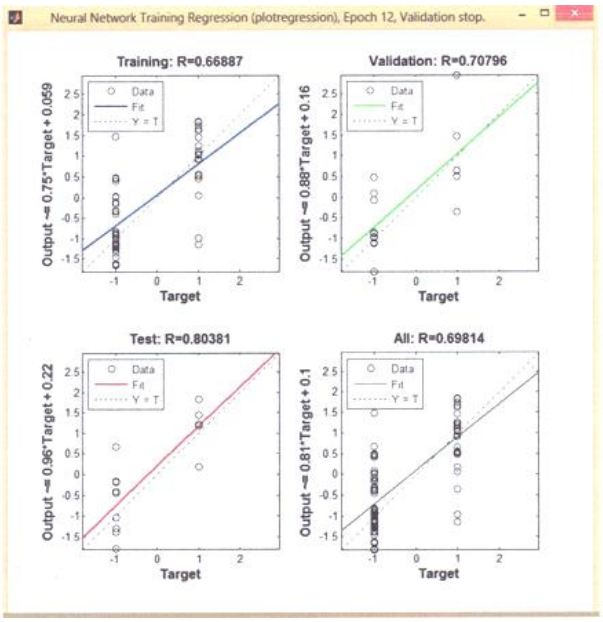

Figure 6.3: Regression Analysis

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