Hybrid Technique for Colour Image Classification and Efficient Retrieval based on Fuzzy Logic and Neural Networks

Ranisha Fernando
School of Science, Information Technology and Engineering
University of Ballarat
Ballarat, Australia
rani3fer@yahoo.com

Siddhivinayak Kulkarni
School of Science, Information Technology and Engineering
University of Ballarat
Ballarat, Australia
S.Kulkarni@ballarat.edu.au

Abstract— **Developments in the technology and the Internet have led to increase in number of digital images and videos. Thousands of images are added to WWW every day. To retrieve the specific images efficiently from database or from Internet is becoming a challenge now a day. As a result, the necessity of retrieving images has emerged to be important to various professional areas. This paper proposes a novel fuzzy approach to classify the colour images based on their content, to pose a query in terms of natural language and fuse the queries based on neural networks for fast and efficient retrieval. Number of experiments was conducted for classification and retrieval of images on sets of images and promising results were obtained. The results were analysed and compared with other similar image retrieval system.**

Keywords-image retrieval; fuzzy logic; neural networks; classification

I. INTRODUCTION

Advances in technology have provided creation, storage and share of the digital information including images and videos. The rapid increase in digital information has led to its own problems in the image retrieval process.

Images are vital part of everyday life in many professional areas. Further, colour images have disctintive features which are used in the research to extract the features for matching purposes. Lot of research interest has been arisen into this area of image retrieval which is done automatically on the basis of colour, texture, shape or abstract features which a technology is referred to as content-based image retrieval or CBIR. Content based image retrieval application areas are commercial areas, crime prevention including fingerprint and face recognition, intellectually property including trade marking, journalism and advertising and web searching.

Most of the image retrieval systems are based on example image as query. However, this research proposes query in terms of natural language content as very low, low, medium, high and very high. These natural language terms are used along with fuzzy logic to acquire the desired results. The importance of this research is that the users are given freedom to pose the query in terms of natural language and a novel technique of fusion of queries using neural networks has been proposed. Experiments were conducted on large image dataset and promising results were obtained.

The rest of paper is organized as follows. Section 2 deals with literature review and related work in this area, Section 3 describes the fuzzy classification, Section 4 deals with neural based fusion of classes, Section 5 details experimental results while Section 6 compares the result with other existing CBIR system and Section 7 concludes the paper.

II. RELATED WORK

Most of the Content-based Image Retrieval (CBIR) systems such as QBIC [1], Virage [2], Photobook [3] and Netra [4] use a weighted linear method to combine similarity measurements of different feature classes. Stricker and Dimai's method [5] segments each image into five partially overlapping fuzzy regions and extracts first two colour moments of each region both weighted by membership functions of the region to form a feature vector for the image. A colour space for CBIR is presented which provides both the ability to measure similarity using fuzzy logic and psychologically based set theoretic similarity measurement. These properties are shown to be equal or superior to the conventional colour space. C. Vertan et al. propose fuzzy colour histogram that classifies fuzzy techniques as crude fuzzy, fuzzy paradigm based, fuzzy aggregational and fuzzy inferential [6].

The Fuzzy Hamming Distance (FHD) is an extension of Hamming Distance for real valued vectors. Because the feature space of each image is a real-valued, the fuzzy Hamming Distance can be successfully used as image similarity measure. FHD is applied for colour histograms of the two images. The authors claim that FHD not only considers the number of different colours but also the magnitude of this difference [7]. In [8] supports concept-based image retrieval as well as the inexact match with a fuzzy triple matching performed when evaluating queries.

In [9] an image is represented by a set of segmented regions each of which is characterised by a fuzzy feature reflecting colour, texture and shape properties. The resemblance between two images is then defined as the overall similarity between two families of fuzzy features and quantified by unified feature matching. Non-Boolean fuzzy and similarity predicates are used to rank tuples according to fuzzy based algebra [10]. Soft queries in image retrieval systems present the use of soft computing and user defined classifications in multimedia database systems for content based queries [11]. A CBIR system which automatically clusters images using features of those images which are fuzzy in nature. The resultant clusters must be described by linguistic variables which are more meaningful to humans than traditional approaches, also fuzzy features result in better clustering than traditional approach. Fuzzy image labelling method that assigns multiple semantic labels together with confidence measures to each region in an image [12]. E. Walker describes several aspects of Internet information retrieval where fuzzy logic can be applied [13]. Not much work has been done in the area of fuzzy logic based linguistic queries for image retrieval. Fuzzy logic has impressive power to represent the queries in terms of natural content of the image. The next section describes the proposed technique of posing the queries in terms of natural language for colour and texture features.

Colour and texture features are extracted using colour median filtering and computed from gray-scale version of the image respectively. Fuzzy C-means clustering has been used to retrieve images in this research [14]. For each images, colour and textures features are extracted and clustered to generate regions which demonstrate similar features. Fuzzy logic is used in the image retrieval process. There are three major stages described in the research are using fuzzy logic variable to describe similarity degree of features, using fuzzy logic to describe the weight assignment and proposing an improvement to the Average Area Histogram [15]. According to the paper [16], a new histogram creation method has been proposed and L*a*b* colour space components have been used which are also known as fuzzy sets. The histogram is obtained through linking of fuzzy sets according to 27 fuzzy rules. A small number of bins are used in this research, only 10, to increase the efficiency of the program. The paper [17] suggests the use of fuzzy logic in information retrieval on the internet. The paper suggests the use of several fuzzy logic techniques in different areas. The feature extraction problem can use fuzzy C-means clustering. In the research done in [18] has used an approach of both fuzzy logic and natural language query. According to their research, the use of natural language is compared to an intelligent approach which can be used to interpret human language.

III. FUZZY CLASSIFICATION

Most of the image retrieval systems use the features those are specific for an application. Colour, texture, shape and object are the most prominent features used for retrieving images in CBIR. In this feature extraction stage, colour feature is extracted as RGB (Red, Green and Blue) values. These extracted RGB values are converted into HSV (Hue, Saturation and Value) values. Hue represents the colour (red, blue), Saturation represents the amount of colour (bright red, light red), and Value represents the amount of light (lightness and darkness of a colour).

Colour {Red, Orange, Yellow, Green, Cyan, Blue, Purple, Magenta, Pink, White, Black}

Content {Very low, Low, Medium, High, Very high}

The query is consisted of a colour and type of content in natural language terms. There are total 55 classes (11 colours and 5 content types). In this approach, the user has the opportunity to select the colour and the content type in natural language terms rather than having to use technical terms. The user also has the advantage of retrieving images without having to posses a similar image. Membership function for various fuzzy content is shown in Figure1.

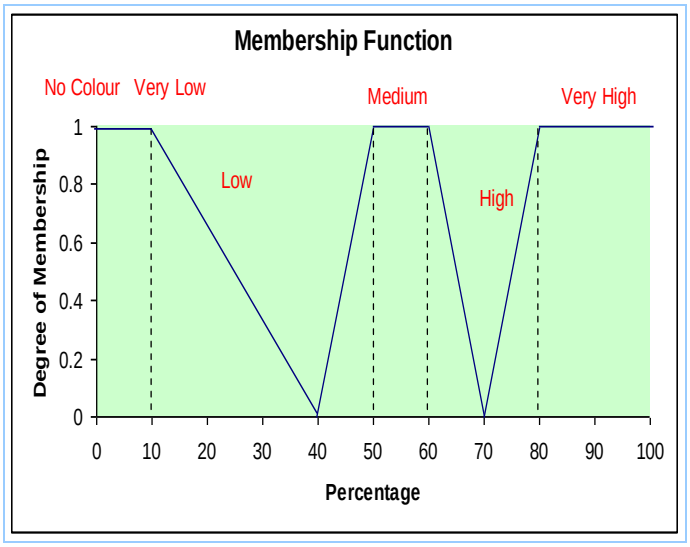

Figure 1. Membership Function used for Fuzzy Image Classification

$$F_{content}(\text{percentage}) = \begin{cases} 1 \text{ if percentage} <= 10 \\ 0 \text{ if percentage} <= 40 \\ \dfrac{40 - \text{percentage}}{(40 - 30)} \end{cases}$$

Figure 1. Membership Function Equation

The above equation is used to calculate content type in terms of fuzzy logic. For the above example equation, if the percentage is between 10% and 40%, the range from $0 < x < 0.5$ is classified as low and $0.5 < x < 1$ is classified as medium. As the above membership function, the following table and figure 20 contains the fuzzy term for the relevant range of percentage. Example shown below shows the procedure to

calculate the degree of membership and decide the correct fuzzy term.

TABLE I. Fuzzy Terms

Percentage	Fuzzy Logic Term
0% – 0.5%	No Significant Colour
0.5% – 10%	Very Low
11% – 35%	Low
36% – 65%	Medium
66% – 80%	High
81% – 100%	Very High

IV. NEURAL BASED FUSION OF CLASSES

It is very important to learn the meaning of the classes for fusion of queries. A neural network based technique is the best solution to learn those classes. Different neural network algorithms can be categorized by, for example, the learning method and architecture of the network. The supervised learning neural network is efficient to learn the colours and content types. Concept of neural network ensemble has been used to implement the fusion of classes. Neural Network Ensembles (NNE) divide the data into smaller areas and becomes easier to learn the meaning of each class. NNE is robust compared to single neural network for processing large amount of data and therefore produces better final decision.
Separate neural networks were formed for each of the content type ranging from very low to very high.
Fuzzy class for colour contents for each image:
very low [0.05, 0.1]
low [0.11, 0.35]
medium [0.36, 0.65]
high [0.66, 0.80]
very high [0.81, 1.0]
As each of the neural networks is learned on classes and not on the database, it avoids retraining of the neural networks.

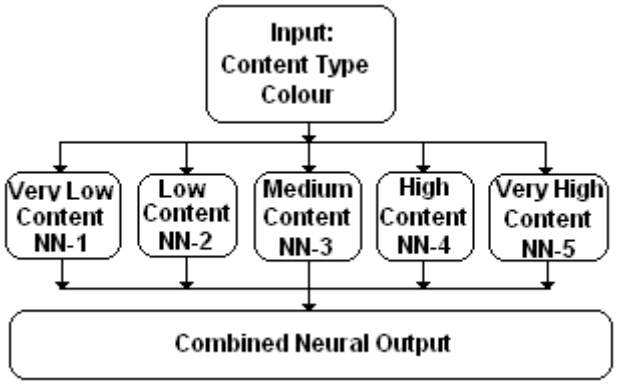

Figure 2. Neural based Fusion

NN indicates the Neural Network designed for a specific content.

V. EXPERIMENTAL RESULTS

A. Image Dataset Preparation and Feature Extraction

Image Dataset consists of five thousand images. These images are taken from various categories such as images of babies, beaches, birds, boats, cars, dogs, fireworks, flowers, landmarks, nature, planes, planets, sunsets, waterfalls and weddings. Number of experiments were conducted by varies queries and some of the results are mentioned in this section.

Table II shows percentage of colours for an image in database. The image contains very high content for cyan and other colours are in low content category.

TABLE II. EXAMPLE IMAGE AND COLOUR CONTENTS

Image	Percentage
	Red = 3.49%
	Yellow = 2.53%
	Green = 5.38%
	Cyan = 82.94%
	Blue = 5.28%
	Magenta = 0.37%

B. Image Retrieval for Single Query

In the image retrieval section, the images retrieved are based on the query submitted by the user. In the below example, the query submitted was medium as the content type and blue as the desired colour.

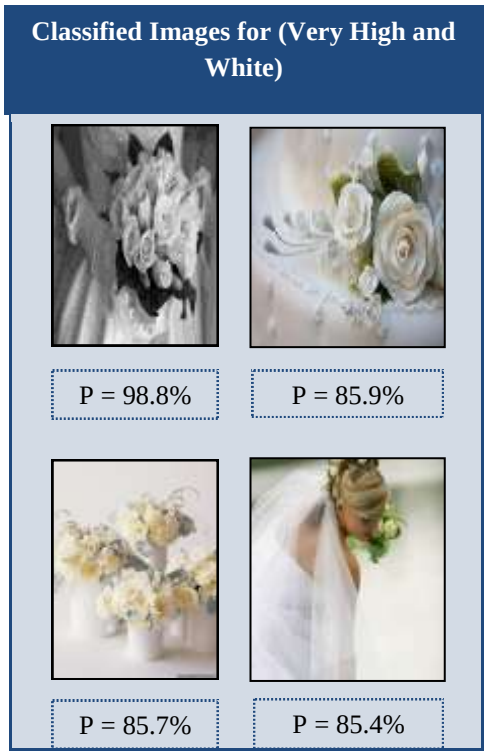

Figure 3. Results for Single Query: White + Very High

The percentage of blue is also displayed at the bottom of each image. These images are ranked in descending order and retrieved accordingly. For ease of display, only top four images are displayed.

C. Fusion of Queries using Neural Networks

The natural language query is used to match with the image in the image set and the relevant images will be classified into the query class. First experiments were conducted on single colour and query type and later results were fused using combination of neural networks based on content type. The classified image will be retrieved and shown in descending order long with their percentage for the relevant colour. For example, if user provides Medium + Blue and Medium Green, the names of the images are listed with the percentages which have a medium content of Blue and Green colours.

The images are retrieved with their percentage. Each percentage is used for indexing. Sorting algorithm is used and the percentages are sorted in descending order. The classified images are then displayed in descending order.

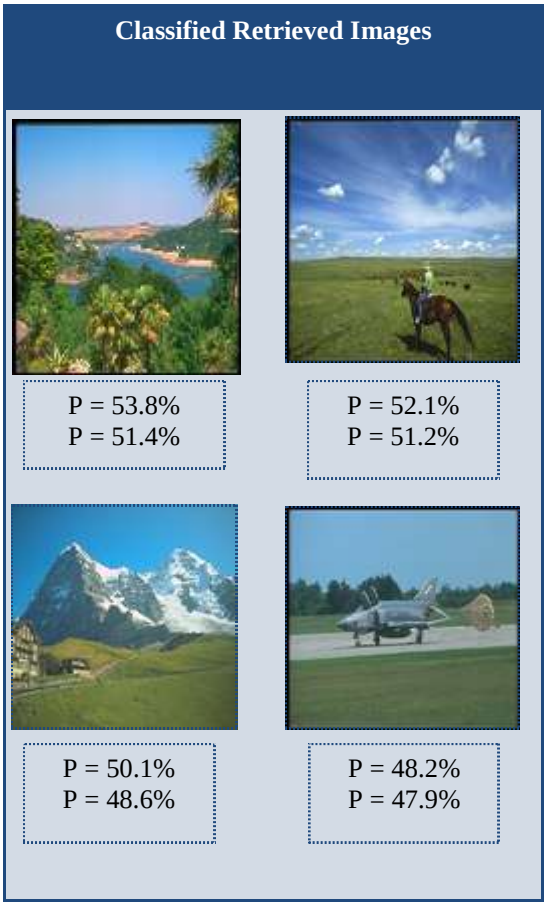

Figure 4. Image Retrieval Results using Multiple Queries

VI. ANALYSIS AND COMPARISON

This section discusses analysis and comparison of the results obtained in the last section, experimental results. The feature extraction is done to significant number of images (about five thousand) to check the accuracy of the proposed system. The retrieval is also done using a significant number of images which are the same images used in feature extraction.

Proposed CBIR system was compared with IBM'S Query By Image Content) QBIC. Firstly, the required colour is selected and retrieval is performed.

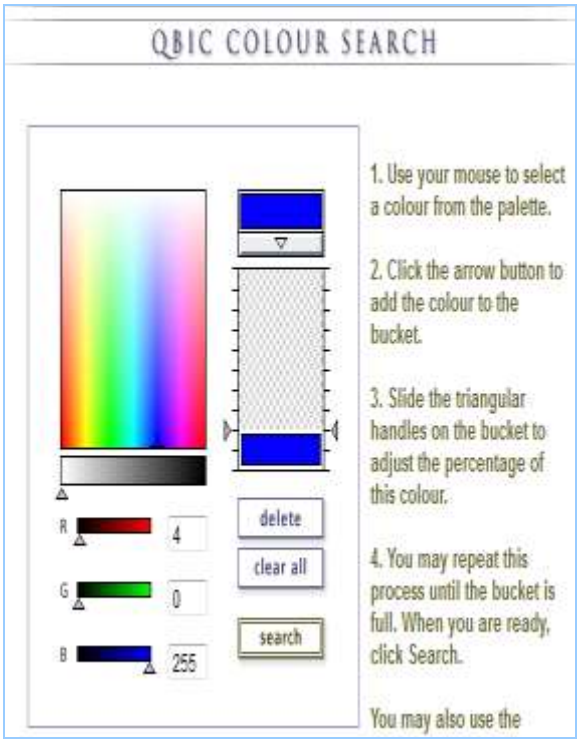

Figure 5. IBM QBIC

The following screenshot contains the images searched as a part of above query. When we check the images below, it shows that the images contain 'blue' select as the query.

Figure 6. IBM QBIC Search Results

Using the same images, proposed image retrieval system used query blue (colour) and high (content). The following example represents the image which contains a high content of blue from the above ten images. Only the highest matched image will be retrieved due to less number of images used in this comparison.

Figure 7: Search Results with Proposed Fuzzy Neural Technique

IBM's CBIR approach displays all the images which contain colour blue. In proposed research, user can pose a query in terms of content of an image such as high/low of specific colour and challenging results were obtained.

VII. CONCLUSION

The proposed CBIR system used fuzzy logic for classification of images into various classes such as very low, low, medium, high and very high. Each image may classify into number of classes depending upon the content of each colour. This classification is effectively used for searching images which contain large number of images in image database. The proposed technique worked well for single query in terms of colour and content type and later extended for multiple queries. These queries are fused using neural based fusion technique. Experiments were conducted for fuzzy image classification, single query retrieval and for multiple queries. Results were compared and analysed with other similar existing technique of CBIR.

REFERENCES

[1] M. Flickner, H. Sawhney, W. Niblack, J. Ashley, Q. Huang, B. Dom, M. Gorkani, J. Hafner, D. Lee, D. Petkovic, D. Steele and P. Yanker, Query By Image and Video Content: The QBIC System, *IEEE Computer*, Vol. 28, Number 9, pp. 23-32, September 1995.

[2] A. Gupta, Visual Information Retrieval: A Virage Perspective, *Technical Report Revision 4*, Virage Inc, San Diego, CA 92121, 1996, URL: http://www.virage.com/wpaper.

[3] A. Pentland, R. Picard and S. Sclaroff, Photobook: Content-based Manipulation of Image Databases, *International Journal of Computer Vision*, Vol. 3, pp. 233-254, 1996.

[4] W. Ma and B. Manjunath, NETRA: A Toolbox for Navigating Large Image Databases, *Journal of ACM Multimedia Systems*, Vol. 7, Number 3, pp.184-198, 1999.

[5] M. Sticker, and A. Dimai, Spectral Covariance and Fuzzy Regions for Image Indexing, *Machine Vision Application*, Vol. 10, pp. 66-73, 1997.

[6] C. Vertan and N. Boujemaa, Embedding Fuzzy Logic for Image Retrieval, *19th International Conference of the North American*, pp. 85-89, 2000.

[7] M. Ionescu, and A. Ralescu, Image Clustering for a Fuzzy Hamming Distance based CBIR Systems, *Proceedings of the Sixteen Midwest Artificial Intelligence and Cognitive Science Conference, MAICS-2005*, pp. 102-108, 2005.

[8] J. Yang, An Image Retrieval Model based on Fuzzy Triples, *Journal on Fuzzy Sets and Systems*, Vol. 121, No. 3, pp. 459 – 470, 2001.

[9] Y. Chen and J. Wang, A Region based Fuzzy Feature Matching Approach to Content based Image Retrieval, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 24, No. 9, pp. 1252-1267, 2002.

[10] P. Ciaccia, D. Montesi, W. Penzo, and A. Trombetta. Fuzzy Query Languages for Multimedia Data. *Book Chapter in Design and Management of Multimedia Information Systems: Opportunities and Challenges*, M.R. Syed Ed., Idea Group Publishing, Hershey, PA, USA, 2001.

[11] C. Shahabi, and Y.Chen, Soft Query in Image Retrieval Systems, *Proceedings of the SPIE Internet Imaging (EI14), Electronic Imaging, Science and Technology*, San Jose, California, pp. 57-68, 2000.

[12] M. Paterno, F. Lim, and W. Leow, Fuzzy Semantic Labelling for Image Retrieval, *International Conference on Multimedia and Expo*, Vol. 2, pp. 767-770, 2004.

[13] E. Walker, Image Retrieval on the Internet - How can Fuzzy Help? Proceedings of the Annual Conference of the North American Fuzzy Information Processing Society, NAFIPS '00, pp. 526-528, 2002.

[14] Ooi, W.S. & Lim, C.P. (2009). A Fuzzy Clustering Approach to Content-Based Image Retrieval. Workshop on Advances in Intelligent Computing 2009.

[15] Xiaoling, W., & Kanglin, X. (2005). Application of the Fuzzy Logic in Content-based Image Retrieval. *JCS&T*. 5(1), 19-24.

[16] Konstantinidis, K., Gasteratos, A., & Andreadis, I. (2005). Image retrieval based on fuzzy color histogram processing. *Optics Communications*. 248, 375–386.

[17] E. Walker, (2002). Image Retrieval on the Internet - How can Fuzzy Help? Proceedings of the Annual Conference of the North American Fuzzy Information Processing Society, NAFIPS'00, pp. 526-528.

[18] S. Kulkarni, (2010). Natural Language based Fuzzy Queries and Fuzzy Mapping of Feature Database for Image Retrieval. *Journal of Information Technology and Applications*. 4(1), 11-20.