Fuzzy Heuristics in Content Based Image Retrieval

[1]Dr. R. Mohanraj, [2]S. Sri Harsha, [3]Dr. M. Vadivukarassi
[1,2,3] Associate professor,
[1,2] Department of Computer Science and Engineering (AI & ML), [3]Department of CSE
[1,2] Sree Venkateshwara College of Engineering and Technology, Chittoor, Andhra Pradesh - 517127
[3]St. Martin's Engineering College, Doolapally Rd, Kompally, Secunderabad, Telangana 500100
1Corresponding Mail id: mohanraj254@gmail.com

Abstract

The field of content based image retrieval has gained steady momentum in recent years due to the growth of diverse digital images in the society. This paper proposes a novel method for retrieving images based on color, texture and shape features controlled by fuzzy heuristics. The color feature is extracted using color auto correlogram. Wavelets like Haar and Daubechies are applied for extracting texture features. The proposed method of obtaining histogram value after Canny edge detection is employed to extract the shape features. The feature values are concatenated. The similarity is analysed using Mahanabolis distance. To obtain more relevant results fuzzy heuristics is applied which acts as a controller in presenting more relevant and similar images as retrieved results. The evaluation of the proposed approach is carried out using the precision and recall measures.

Keywords : Content based image retrieval; Fuzzy logic;

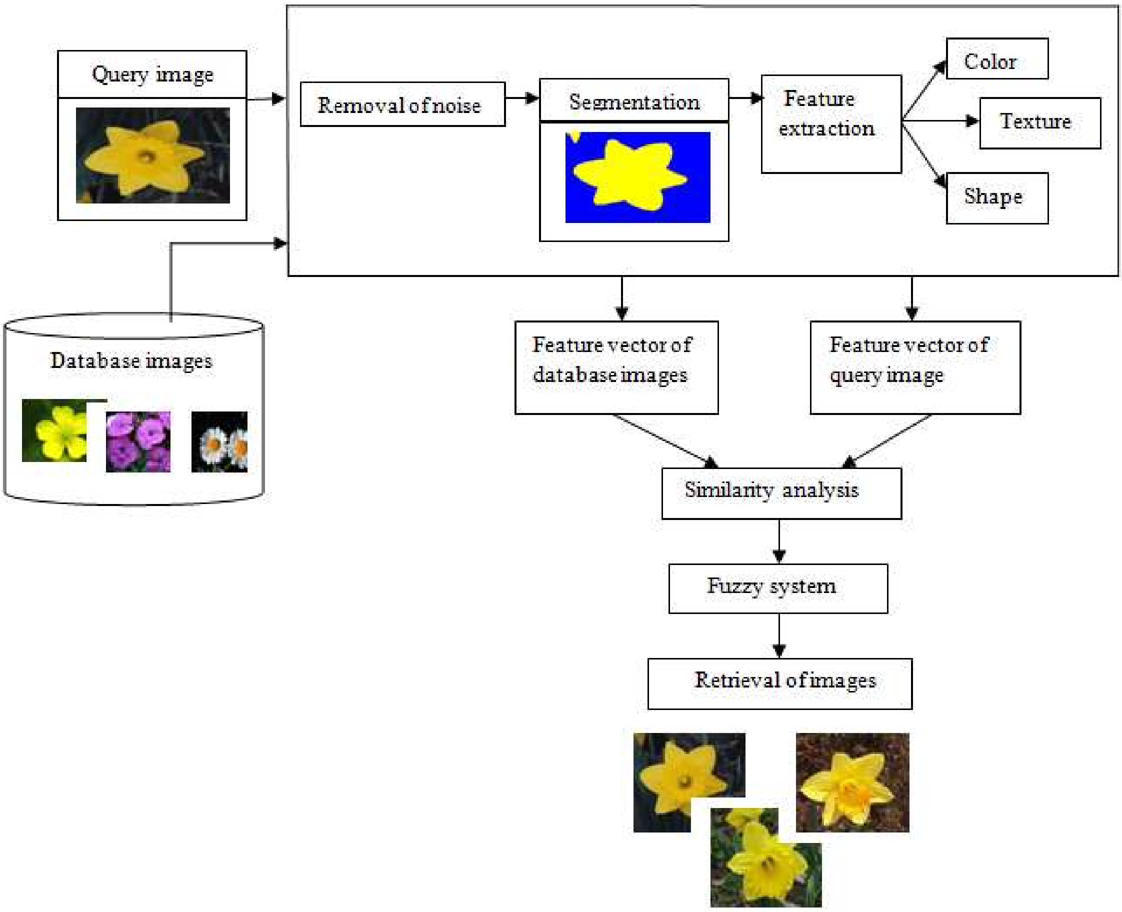
1.. Introduction

In recent years, the development in technology has influenced all aspects of our daily life. Most people have hand held devices capable of capturing and storing large number of digital images. Surveillance cameras have been installed everywhere to capture the faces of humans for maintaining better homeland security. Medical centers are equipped with sophisticated devices for scanning and capturing images for various parts of the body. Due to the latest devices, images are captured and they are stored digitally and hence the storage of the images is growing rapidly. In this context, searching or retrieving an image from digitally stored database, is the need of the day for fulfilling the various necessities [1]. Specifying an image by asset of keywords is known as text annotation. But, employing the text annotation is more impractical in the world of the fastest growing digital images. To overcome the image retrieval problems of annotation based method, this paper proposes a method based on content based image retrieval (CBIR) [2]. This method uses visual contents to index and retrieve similar images from large image database for a given query image [3].

2. Literature review

This paper proposed a content-based image retrieval technique using the combination of color and texture information. Color features are captured using Zernike chromaticity distribution moments. Texture features are extracted using rotation-invariant and scale-invariant image descriptor in Contourlet domain [4].In this article[5], the authors proposed a framework that encompasses image pre-processing, image feature and textual metadata extraction and a patent image search engine in order to support content-based image retrieval in the patent domain. Here, a framework based on relevance feedback to retrieve images iteratively is set both to train the system and to evaluate objective performance measures [6]. This paper [7] used color histogram from HSV color space for color features and co-occurrence matrix for texture features of an image for content-based image retrieval (CBIR). In this study [8], from the selective regions, dominant color and Local Binary Pattern (LBP) based texture features are extracted. Feature vectors together with their region codes are stored and indexed. Feature vectors of regions having region codes similar to the query image region are compared for retrieval of images. In this paper [9], by assigning weight for each dominant color, a new semantic feature extracted from dominant colors and modification to dominant color based similarity measure are also proposed. This paper [10] proposed a method for CBIR called "Class Membership-based Retrieval" which consists of two steps. Initially, the class label and fuzzy class membership of query image is computed using neural network. Next, the retrieval is performed using a combination of simple and weighted distance metric in complete search space. This paper [11] presented a method to extract the feature namely color difference histograms (CDH). This method concentrates on color, edge orientation and perceptually uniform color differences for image retrieval. In [12] a scattered search algorithm based on Non-dominated Sorting Genetic Algorithm is applied at the first iteration of the relevance feedback process, and then switched to an exploitation algorithm for retrieval of the similar images. In their proposal mentioned in [13], an image is represented as being a set of objects, and each object is represented with color, texture and shape descriptors. To extract the semantic content, each object is stored into Concept Object Knowledge Base (COKB) which is constructed using neural learning with adaptive resonance theory networks. A similar image determination model is proposed in this research work [14].

Fig. 1 Block diagram of proposed approach



3.1 Pre- Processing

Firstly, the query image undergoes pre-processing. It is performed to remove the distortions and to enhance the image for further processing [3]. Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. The noise is filtered using Median filter which serves the best for filtering the noise in the proposed system by after having a comparative analysis among the Averaging, Median and Wiener filters based on the PSNR (Peak Signal to Noise Ratio) values.

Median filter is a non linear digital filtering technique, often used to remove salt and pepper noise. It is widely used in digital image processing because under certain conditions, it reserves edges whilst removing noise. Here, the neighboring pixels are ranked according to brightness (intensity) and the median value becomes the new value for the central noisy pixel.

3.2 Feature extraction

Features are measurements of ultimate interest analyzed from an image. A feature is a characteristic which can capture a certain visual property of an image either globally for the entire image or locally for regions or objects. There exist many features like color, shape, texture etc. It is necessary to extract these features from image for analyzing the similarity among different images which is mandatory for retrieving relevant images. Feature extraction is the process of mapping the image pixels into the feature space where it is stored as feature vectors.

a) Color

One of the important features that make possible the recognition of images by human is color. Color is a property which is used for providing discrimination among various objects and hence adopted as the most dominant feature in CBIR (ex: QBIC). Usually colors are defined in three dimensional color spaces. These could be **RGB** (Red, Green, and Blue), **HSV** (Hue, Saturation, and Value) or **HSB** (Hue, Saturation, and Brightness).

b) Color Correlogram

A color correlogram expresses how the spatial correlation of pairs of colors changes with distance. Informally, a correlogram for an image is a table indexed by color pairs, where the d-th entry for row (i,j) specifies the probability of finding a pixel of color j at a distance d from a pixel of color i in this image. Here d is chosen from a set of distance values D. It is based on randomly choosing a pixel 'x' & determining its color , C. Based on which a pixel 'y' at a distance 'k' is considered & the method expects to find the probability of the pixel 'y' to have the same color as that of 'x', i.e. C

c) Texture

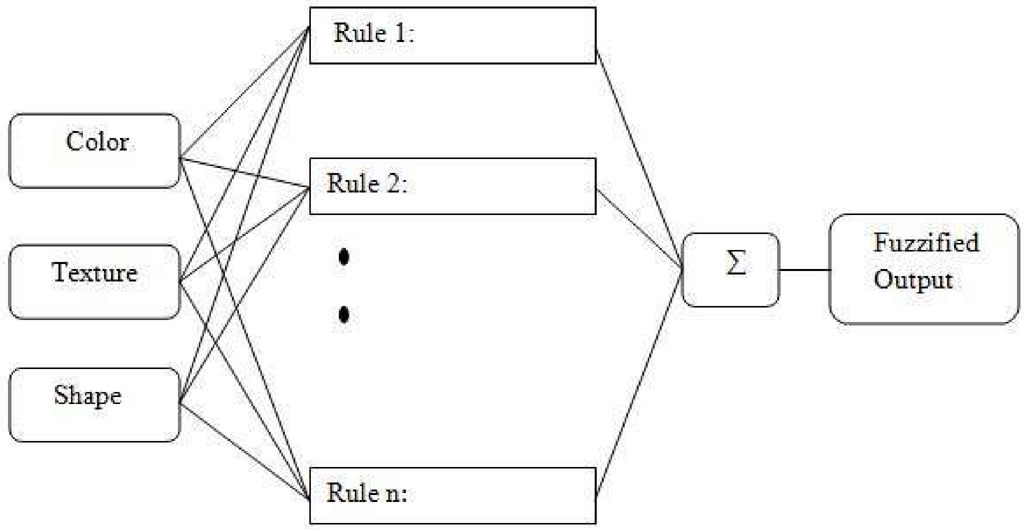
It is one of the main features utilized in image processing and vision which denotes the visual patterns. Texture describes the distinctive physical composition of a surface and contains information about structural arrangement of surface (clouds, leaves, bricks etc).Since an image is composed of pixels, texture can be defined as the entity consisting of mutually related pixels and group of pixels. This group of pixels is called as texture primitives or texture elements referred as *texels*.

3.3 Similarity Analysis

Similarity between two images is measured numerically that reflects the strength of connections between them. Similarity is crucial in obtaining relevant results. To obtain relevant results, various researchers use different methods to measure similarity.. In this proposed system, Mahalanobis distance is used to calculate the similarity between two feature vectors as follows, Closer distance represents the higher similarity between images.

3.4 Fuzzy Logic

Fuzzy logic is applied to measure similarity between the query image and the database images in order to retrieve and display relevant or similar results to the user query. The similarity is analyzed separately for color, texture and shape features and these distance measures for color, texture and shape features serve as the input for fuzzy controller. There are three types of references that are taken into account while checking the similarity between images. The first priority is given to the color features, as these features are invariant to the rotation and translation. The second and third priority is given to the texture and shape features respectively. By defining these criteria along with the fuzzy rules, it is assumed that better results can be achieved using our proposed approach. The Mamdani fuzzy inference method is used to perform fuzzy rules in the proposed approach [11].

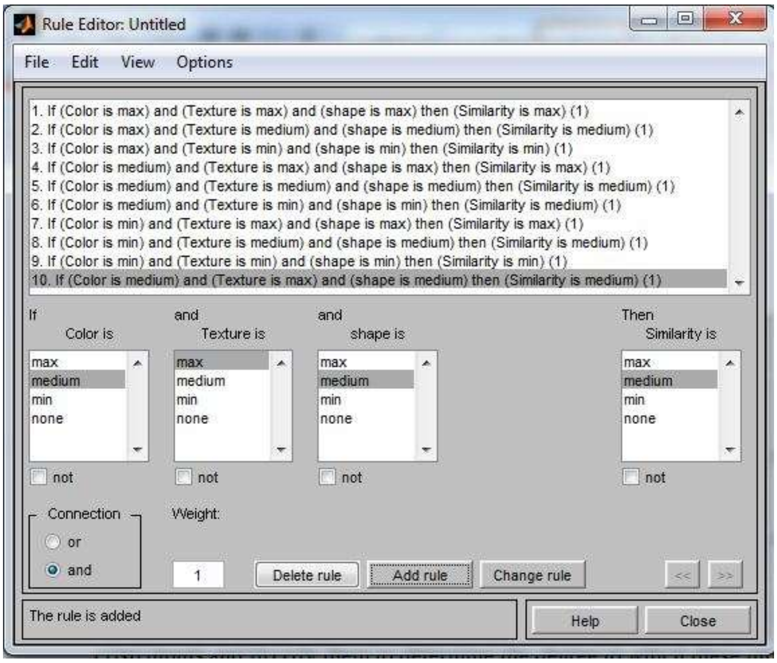


P, Q, R are three visual features of images that have been retrieved using Correlogram, Wavelets and edge detection methods. Based on the Mahalanobis distance algorithm the images are found that have high similarity between query and database image. After obtaining the relevant images to the query image, it is needed to find common images between P, Q *and* R set of images. The common set of images is considered the most relevant images.

By adopting the following steps, we introduce a set of fuzzy rules to process the results achieved by applying the three distinct algorithms as discussed above. The rules and their presentations are shown in Figs. 4 and 5 respectively.

• Step 1: Three inputs are used such as color distance, texture distance and shape distance between query image and database images.

• Step 2: The membership functions for three types of input have been defined. There are three different types of fuzzy set that identified each input as minimum, medium and maximum.



• Step 3: Three types of output fuzzy sets have been declared such as max similar, medium similar and min similar.

• Step 4: A fuzzy rule can be defined as a conditional statement such as if then. Fuzzy rules applied using logical operator.

• Step 5: To process the Mamdani fuzzy inference method. We take the crisp inputs and fuzzify them to determine the degree to which these inputs belong to each of the appropriate fuzzy set.

• Step 6: We have applied the AND fuzzy operator to get one number that represents the result of antecedent of rules. The output is a single truth value.

• Step 7: The process of unification of the output of all the rules that have been used until last step. The output of this step is one fuzzy set for each output variable. The process is called an aggregation.

• Step 8: Lastly the aggregate output fuzzy set should transform to a single crisp number. We used process of defuzzification to done it.

3.5 Performance Measures

The performance of a CBIR system can be measured in terms of its precision and recall. Precision measures the retrieval accuracy; it is the ratio between the number of relevant images retrieved and the total number of images retrieved. Recall measures the ability to retrieve all relevant images in the database. It is the ratio between the number of relevant images retrieved and all of the relevant images in the database.

They are defined as follows:

$$\text{Precision } (P) = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}}$$

$$\text{Recall } (R) = \frac{\text{Number of relevant images retrieved}}{\text{Number of relevant images in database}}$$

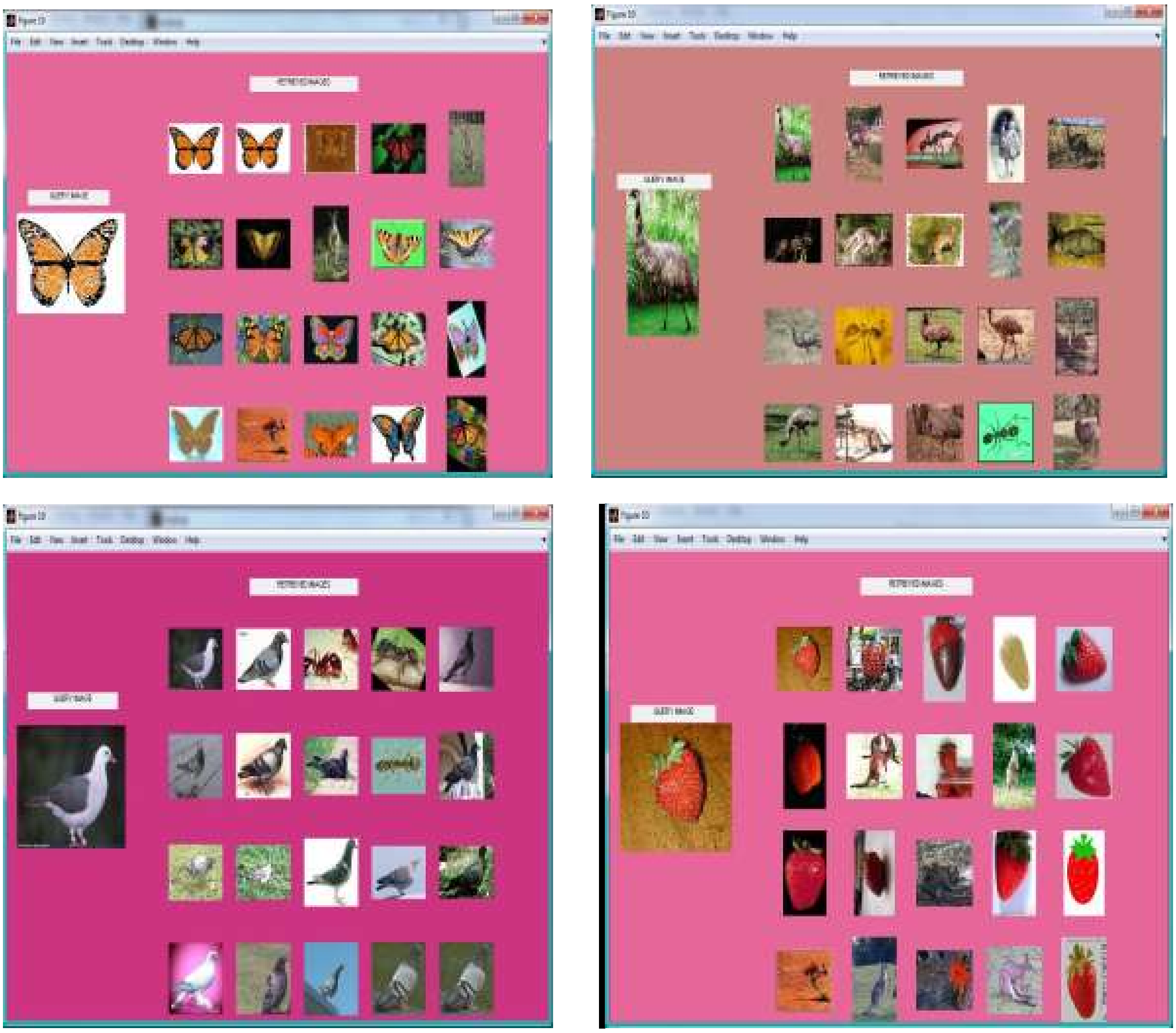
The simulations were taken place in MATLAB. The number of search results may vary depending on the number of similar images in the database. The development of powerful processing, faster and cheaper memories contribute heavily to CBIR growth.

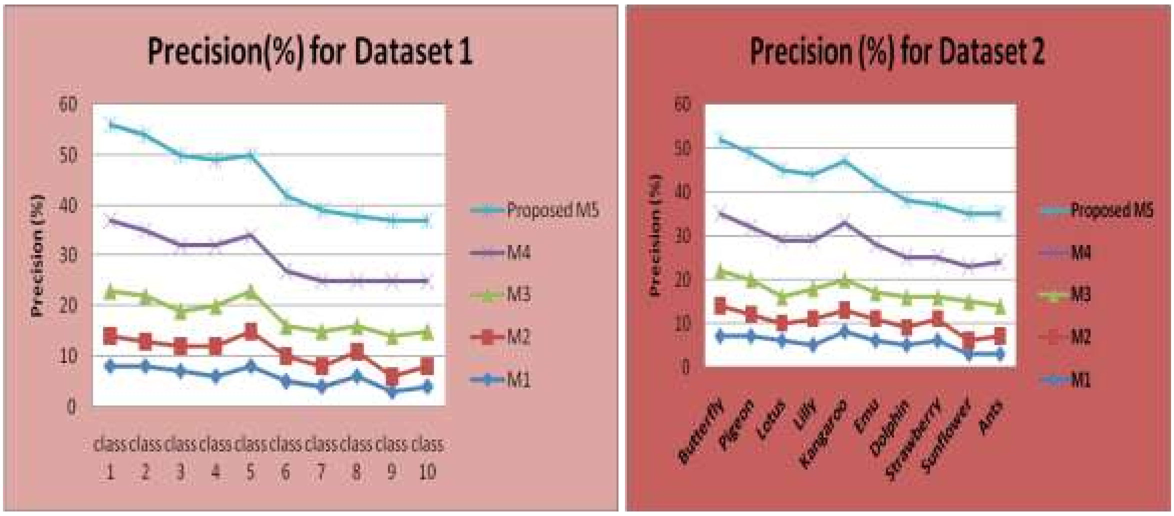
4. Experimental Results

4.1 Datasets used

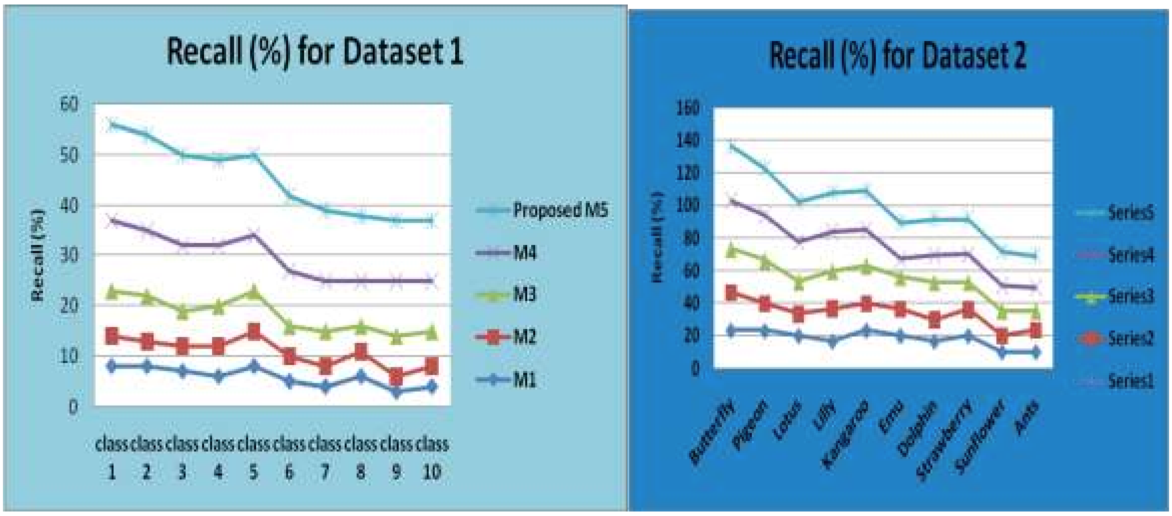
In order to assess the performance of the proposed method, two kinds of datasets such as Oxford flower (dataset 1) and Caltech101 (dataset 2) are applied. In our experiment, ten categories have been selected from Oxford dataset. Each category contains eighty images and a sum of 800 images is taken from Oxford datasets. The size of the image ranges from 300x500 to 500x700. In Caltech101, ten types of categories such as Butterflies, Emu, Kangaroo, and Lotus etc are selected, and thirty five images are taken in each category. Hence 350 images are taken from Caltech101 database. The size of the images is in the range of size of 300x200 to 355x400 pixels.

Retrieval results





Graph showing Precision rate for Datasets (1 and 2)



Graph showing Recall rate for Datasets (1 and 2)

4.2 F-score and Accuracy

To evaluate the most efficient image retrieval, precision and recall scores are combined into a single measure of performance, known as the F-score. Higher values of the F-score are obtained when both precision and recall are higher. The formula for calculating the F-score is:

$$\text{F-score} = \frac{2 * P * R}{P + R}$$

Accuracy rate for proposed system is calculated which is defined as follows:

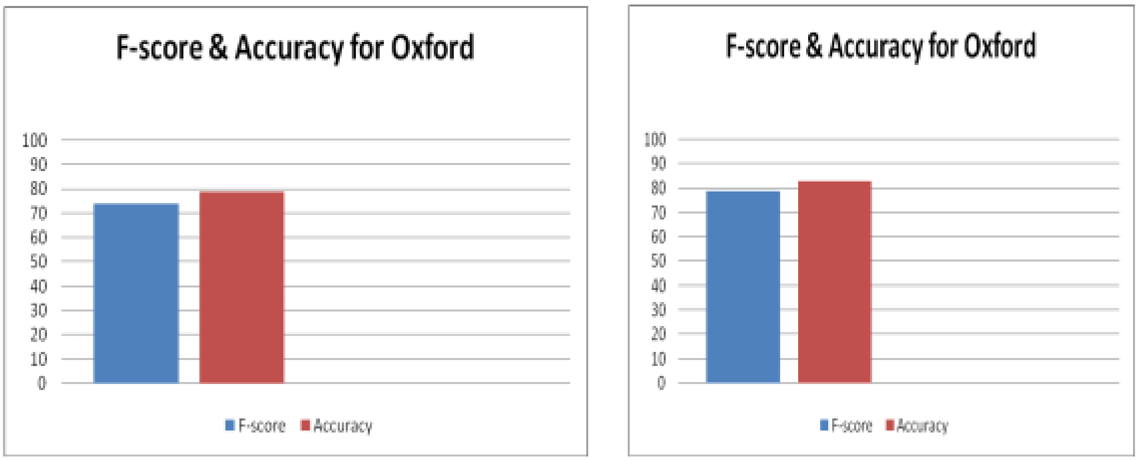
$$\text{Accuracy} = \frac{(P + R)}{2}$$

i) Chart showing f-score and accuracy for Caltech101 datasets

a) F-score and accuracy before the application of fuzzy

b) F-score and accuracy after the application of fuzzy

ii) Chart showing f-score and accuracy for Oxford datasets



a) F-score and accuracy before the application of fuzzy

b) F -score and accuracy after the application of fuzzy

Retrieval time (in seconds)

Techniques used	Retrieval time (seconds)
Method 1 (M1)	2. 056
Method 2 (M2)	2. 133
Method 3 (M3)	2. 126
Method 4 (M4)	2. 863
Method 5 (Proposed M5)	2. 751

5. Conclusion

In this paper, color features are extracted using the latest technique of auto corologram. The texture features are obtaining using the wavelet features like Haarand Daubichies. The novel idea of getting histogram values after the Canny edge detection is proposed. These features are combined to obtain the single feature vector. Similarity measurement is done using Mahanobolis distance. In order to increase more relevant retrieved images, the fuzzy heuristics is applied. Due to the advantages of fuzzy approaches, it is found that the relevant images retrieved are increased. It is observed that the images are to defiend using all visual fetaures like color, texture and shape features.

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