Color Image Segmentation and Recognition based on Shape and Color Features

Rajivkumar Mente,
Department of Computer Science, Solapur University, Solapur
rajivmente@rediffmail.com

B. V. Dhandra, Gururaj Mukarambi,
Department of Computer Science, Gulbarga University, Gulbarga

Abstract – **Recent advances in computer technology have made it possible to create databases for large number of images. A major approach directed towards achieving CBIR is the use of low-level visual features of the image data to segment, index and retrieve relevant images from the image database. Segmentation is the partition of a digital image into regions to simplify the image representation into something that is more meaningful and easier to analyze. Color based segmentation is significantly affected by the choice of color space. In different color spaces, the L*a*b color space is a better representation of the color content of an image. In this paper the L*a*b color space and K-means algorithm is used for segmentation of color images. Shape description or representation is an important issue both in object recognition and classification. After segmentation this paper focuses on the shape descriptor-eccentricity and color features for achieving efficient and effective retrieval performance. The proposed method is applied to an image database containing 2600 fruit images.**

Keywords – Segmentation, Clustering, L*a*b, Color space, Eccentricity, kNN, Canny Edge Detection

I. INTRODUCTION

"Segmentation" refers the process of dividing an image into distinct regions with property that each region is characterized unique feature such as intensity, color etc. Further it refers to the process of dividing a digital image into multiple segments such as sets of pixels [1]. Image segmentation may be defined as a process of assigning pixels to homogenous and disjoint regions which form a partition of the image that share certain visual characteristics [2]. It basically aims at dividing an image into subparts based on certain feature. Features could be based on certain boundaries, contour, color, intensity or texture pattern, geometric shape or any other pattern[3]. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image[4]. Region growing approach used for segmentation examines neighboring pixels of initial "seed points" and determines whether the pixel neighbors should be added to the region[5]. Segmentation is application dependent because it needs image interpretation (e.g. locating objects or object boundary, lines etc). So it can be used in applications which involve a particular kind of object recognition such as

- Multimedia applications
- Industry applications (Airport security system, Automatic car assembly in robotic vision)
- Face recognition
- Fingerprint recognition
- Locating objects in satellite images

In the color image segmentation, a proper choice of color space is very important. For experiment CIE L*a*b color space is chosen due to its three major properties 1. Separation of achromatic information from chromatic information. 2. Uniform color space and 3. Similar to human visual perception. Here L* represents the luminance component, while a* and b* represent color components[6]. The most popular method for image segmentation is K-means Clustering algorithm. It is a widely used algorithm for image segmentation because of its ability to cluster huge data points very quickly. [7][8][9].

Applications like medicine, entertainment, education etc. make of vast amount of visual data in the form images. The features such as luminance, shape descriptor and gray scale texture are some natural features since they correspond to visual appearance of an image[10][11][12]. A popular CBIR developed at IBM, it uses eccentricity, circularity, shape area, major axis orientation and a set of algebraic moment invariants for shape representation [13]. An image retrieval system recognizes an image from the database similar to that of query image in terms of shape, color and texture [14-17]. By considering only the color features in different regions of an image, the image retrieval accuracy achieved is up to 93.53 percent [12]. Shape is an important feature for perceptual object recognition and classification of images. It has been used in CBIR in conjunction with color. The proposed method in this paper uses the shape descriptor-eccentricity and mean of pixel values in the red, green and blue color space for achieving efficient and effective retrieval performance and to increase the accuracy in the image retrieval and recognition.

II. THE BASIC THEORY OF K-MEANS CLUSTERING

This section briefly explains the basic theory of K-means clustering. K-means is an unsupervised clustering algorithm which is frequently used in image processing. It follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters). Let $A=\{a_i \mid i=1,\ldots,f\}$ be attributes of f-dimensional vectors and $X=\{x_i \mid i=1,\ldots,N\}$ be each data of A. The K-means clustering separates X into k partitions called clusters $S=\{s_i \mid i=1,\ldots,k\}$ where $M \in X$ is $M_i=\{m_{ij} \mid j=1,\ldots, n(s_i)\}$ as members of s_i, where $n(s_i)$ is number of members for s_i. Each cluster has cluster center of $C=\{c_i \mid i=1,\ldots,k\}$. K-means clustering algorithm can be described as follows [11]:

1. Initiate its algorithm by generating random starting points of initial centroids C.
2. Calculate the distance d between X to cluster center C. Euclidean distance is commonly used to express the distance.
3. Separate x_i for i =1 . . N into S in which it has minimum $d(x_i, C)$.
4. Determine the new cluster centers c_i for i=1..k defined as:

$$c_i = \frac{1}{n_i}\sum_{j=1}^{n(s_i)} m_{ij} \in s_i$$

5. Go back to step 2 until all centroids are convergent.

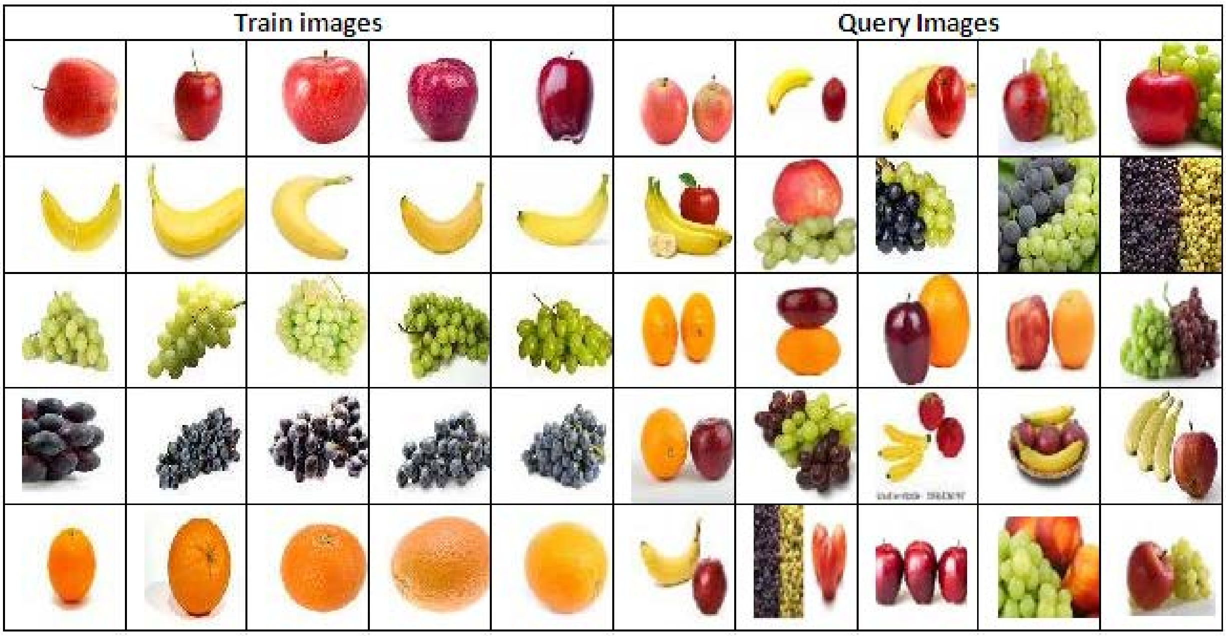
III. EDGE DETECTION

Edges define the boundaries between regions in an image [18]. It detects the edges of the objects. Edge detection helps in image segmentation and object recognition[19]. Edge detection produces an edge map which contains important information about the image. There are many ways to perform edge detection. One of them is gradient based edge detection and second one is Laplacian based edge detection[20]. Various popular edge detection techniques are available, for example Sobel Edge Detection, Prewitt Edge Detection, Robert Edge Detection, Canny Edge Detection etc.[21]. However, Canny's Edge Detection algorithm performs better than Sobel and Prewitt Operators[22]. The Canny Edge Detector is widely considered as the standard Edge Detection algorithm in image processing[23]. Therefore during experiments as given in the algorithm 5.1 before calculating the eccentricity Canny Edge Detector algorithm is applied to find the edges in an image.

IV. IMAGE DATABASE

For experiment purpose a large database of images is used. In this paper eccentricity and mean values of each color space is used as features of image for retrieval from the image database. The database consists of 2600 different single fruit images and multifruit images downloaded from the internet as shown in Table 4.1.

Table 4.1 : Some Train and Query Images



V. METHODOLOGY

The basic aim is to segment images in an automated fashion using the L*a*b color space and K-means clustering and then recognize the segmented image and assign label to it. The entire process is summarized in following algorithm 5.1 and algorithm 5.2.

Alogrithm 5.1 : Algorithm to extract the features of training / segmented images –

Step 1 : Start

Step 2 : Input the color training / segmented image.

Step 3 : Convert this image into gray.

Step 4 : Filter out the noise from the image using median filter.

Step 5 : Apply the Canny’s Edge Detector method to find edges.

Step 6 : Calculate the eccentricity of the image.

Step 7 : Calculate mean of each color space i.e. red, green and blue

Step 8 : Label the image.

Step 9 : Store eccentricity and mean of each color space as vector in the feature matrix.

Step 10 : Store label of image and index of image as vector in other matrix.

Step 11 : Repeat step 2 to step 10 for each training / segmented image.

Step 12 : Stop

Alogrithm 5.2 : Algorithm to segment the query image and recognize segmented images

Step 1: Read the image

Step 2: Convert Image from RGB Color Space to L*a*b* Color Space

Step 3: Classify the colors in 'a*b*' space using K-Means Clustering. Clustering is a way to separate groups of objects. K-means clustering treats each object as having a location in space. It finds partitions such that objects

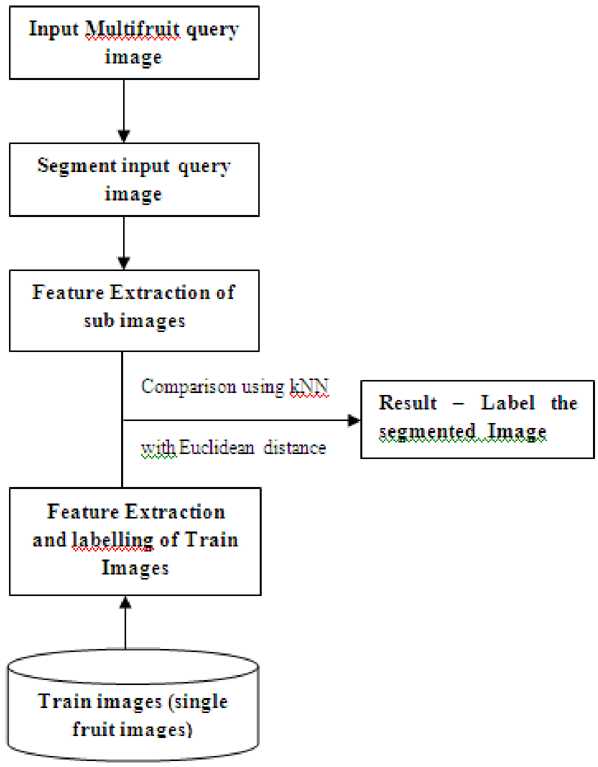


Figure 5.1 : Work flow diagram

within each cluster are as close to each other as possible, and as far from objects in other clusters as possible. K-means clustering requires that you specify the number of clusters to be partitioned and a distance metric to quantify how close two objects are to each other. Since the color information exists in the 'a*b*' space, your objects are pixels with 'a*' and 'b*' values. Use kmeans to cluster the objects into three clusters using the Euclidean distance metric.

Step 4: Label Every Pixel in the Image Using the Results from Kmeans. For every object in your input, K-means returns an index corresponding to a cluster. The cluster_center output from kmeans will be used later in the example. Label every pixel in the image with its cluster_index.

Step 5: Create Images that Segment the Image by Color.

Using pixel_labels, you can separate objects in the image by color, which will result in three images.

Step 6: Segment the objects into a Separate Image

Step 7: Use algorithm 4.1 to extract shape descriptor: eccentricity and color features.

Step 8: The features of segmented images are compared with features of training images by using kNN with Euclidean Minimum Distance measure.

Step 9: The index returned by operation in step-8 is the index of nearest matching features from the feature matrix of training images. The index retrieved and the matrix of labels of training images is used to label the segmented image.

VI. EXPERIMENTAL RESULT

A simple GUI is designed to implement the above methodology which is shown in the figure 6.1 along with the recognition of the sub images of inputted query image. To use this GUI, first select the input multifruit query image by clicking the ‘Input Query Image’ button. This will segment it into subimage-1, subimage-2 and subimage-3 as shown in figure 6.1. After this to recognize / label these subimages click the corresponding ‘Label Image’ button.

VII. CONCLUSION

The proposed method gives more perceptually satisfactory segmentation and recognition results. Initially the multifruit query color image is segmented into meaningful objects by using the proposed method in this paper. K-means clustering combines pixels with similar color for segmentation of the image into objects. It is possible to reduce the computational cost avoiding feature calculation for every pixel in the image by using color based image segmentation. After segmentation the method is proposed to retrieve segmented image based on the shape descriptor: eccentricity and three mean of intensity values of red, green and blue color space. The results and performance of retrieval of the method given in this paper is effective and efficient. Texture features can be further used to enhance the retrieval.

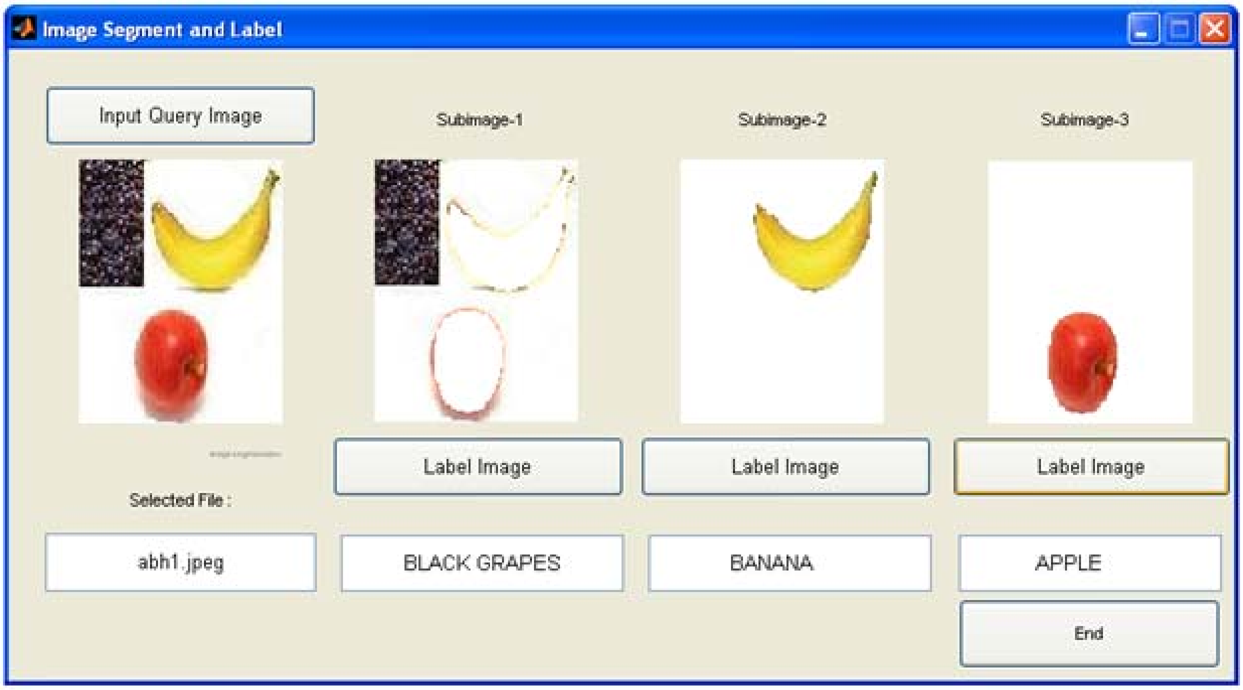


Figure 6.1 : GUI for segmenting and labeling the multifruit query image

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