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Color Image Segmentation By Clustering

[I]Neelambike S, [II]Parashuram Baraki
[I]Dept of Information Science and Engg, Asst. Professor, GMIT, Davangere, India
[II]Dept of Computer Science and Engg, Asst. Professor, GMIT, Davangere, India
Email : [I]neelais@gmail.com, [II]parashuram.baraki@gmail.com

Abstract
In this paper we have described an algorithm, which are used for segmentation of color images with clustering methods. This algorithm is tested on ten color images, which are firstly transformed to RGB color space. Conditions, results and conclusions are described below. The results are compared by using both Mahalanobis and Euclidean distances in the clustering algorithm.

Keywords
Color image Segmentation, Clustering, Euclidean distance

I. Introduction

Image segmentation is a major Research topic in the field of Image processing. Most of the computer vision image analysis problem requires segmentation stage in order to detect object and divide the image into regions which can be consider as homogeneous according to color, motion, texture etc. [1]
Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters).

II. Image Segmentation

It is the process of partitioning a digital image into multiple groups or segments. The main goal of segmentation is to simplify the image or change the representation of an image into more easier to analyze [3] and must be meaningful. Image segmentation is used to locate lines, curves etc in images. Image segmentation is the process of giving a label to every pixel in an image.
Image segmentation is the first step in image analysis and pattern recognition. It is a critical and essential component of image analysis system, is one of the most difficult tasks in image processing, and determines the quality of the final result of analysis. Image segmentation is the process of dividing an image into different regions such that each region is homogeneous.
Image segmentation methods can be categorized as below

- Region Based Methods
- Edge Based Methods
- Hybrid Techniques

A. Region Based Techniques

Region based methods are based continuity. These techniques divide the entire image into sub regions depending on some rules like all the pixels in one region must have the same gray level. Region-based techniques rely on common patterns in intensity values within a cluster of neighbouring pixels[2]. The cluster is referred to as the region, and the goal of the segmentation algorithm is to group the regions according to their anatomical or functional roles.

B. Edge Based Techniques

Segmentation Methods based on Discontinuity find for abrupt changes in the intensity value. These methods are called as Edge or Boundary based methods. Edge detection is the problem of fundamental importance in image analysis. Edge detection techniques are generally used for finding discontinuities in gray level images[4]. Edge detection is the most common approach for detecting meaningful discontinuities in the gray level. Image segmentation methods for detecting discontinuities are boundary based methods. Edge detection can be done using either of the following methods. Edges are local changes in the image intensity. Edges typically occur on the boundary between two regions. Important features can be extracted from the edges of an image (e.g., corners, lines, curves).Edge detection is an important feature for image analysis. These features are used by higher-level computer vision algorithms (e.g., recognition). Edge detection is used for object detection which serves various applications like medical image processing, biometrics etc. Edge detection is an active area of research, as it facilitates higher level image analysis. There are three different types of discontinuities in the grey level like point, line and edges. Spatial masks can be used to detect all the three types of discontinuities in an image.

C. Hybrid Techniques

This hybrid Techniques consider both edges and regions.

III. Color Image Segmentation By Clustering

Clustering is a classification techniques. Given a vector of N measurements describing each pixel or group of pixels (i.e., region) in an image, a similarity of the measurement vectors and therefore their clustering in the N-dimensional measurement space implies similarity of the corresponding pixels or pixel groups. Therefore, clustering in measurement space may be an indicator of similarity of image regions, and may be used for segmentation purposes.
The vector of measurements describes some useful image feature and thus is also known as a feature vector. Similarity between image regions or pixels implies clustering (small separation distances) in the feature space. Clustering methods were some of the earliest data segmentation techniques to be developed.

IV. Most Commonly Used Clustering Algorithms

A. K-means

K-means is one of the simplest unsupervised learning algorithm that partition feature vectors into k-clusters so that the within group sum of squares is minimized. The procedure follows a simple way to classify a given data set and looks like that:
Step 1: Start
Step 2: Place randomly initial group centroids
Step 3: Assign each object to the group that has the closest

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Centroid
Step 4: If the positions of the centroids didn't change go to the next step else go to step 2.
Step 5: End.
So, using this K-mean algorithm generates the clusters by using the centroids and distance. Which data point is very close to the centroids that data point belongs to that cluster.

B. Hierarchical Clustering

Hierarchical clustering techniques proceed either from the top to the bottom or from the bottom to the top, i.e., a technique starts with one large cluster and splits it, or starts with clusters each containing a point, and then merges them.

C. K-medoids:

Color image segmentation procedure:
Input the image.
Inputted image transfers into a feature space.
Apply clustering algorithm for feature space.
Each cluster is divided into number of segments.

Graphical representation of color image segmentation:

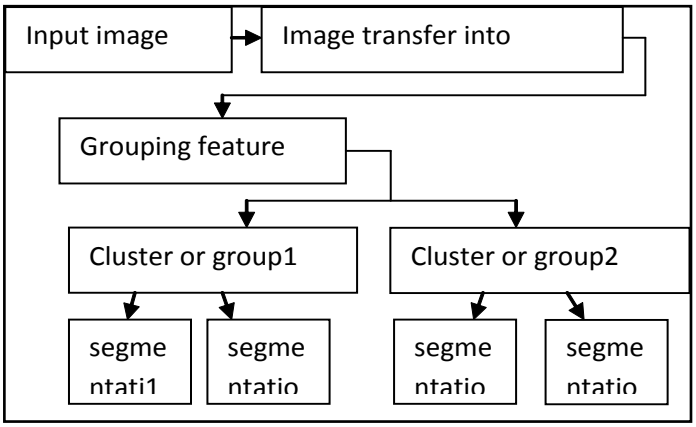

Fig 1: graphical representation of color image segmentation

From the above fig1 performs the following procedure for color image segmentation
Step 1: First, an image is taken as an input. The input image is in the form of pixels and is transformed into a feature space (RGB).
Step 2: Next similar data points, i.e. the points which have similar color, are grouped together using any clustering method. A clustering method such as k-means clustering is used to form clusters as shown in the flow chart. The distances are calculated using Mahalanobis and Euclidean distance.
Step 3:
After clustering is done, the mean of the clusters is taken. Then the mean color in each cluster is calculated to be remapped onto the image.

V. Experimental Result

Both Mahalanobis and Euclidean distances are described below clearly.

Mahalanobis Distance:

- Mahalanobis Distance is a very useful way of determining the "similarity" of a set of values from an "unknown": sample to a set of values measured from a collection of "known" samples.
- Superior to Euclidean distance because it takes distribution of the points (correlations) into account.
- Traditionally to classify observations into different groups.
- It takes into account not only the average value but also its variance and the covariance of the variables measured.
- It compensates for interactions (covariance) between variables.
- It is dimensionless.

The formula used to calculate Mahalanobis distance is given below.
$Dt(x) = (x - Ci) * Inverse(S) * (x - Ci)`$

Here, X -It is a data point in the 3-D RGB space,
Ci – It is the center of a cluster.
S - It is the covariance matrix of the data points in the 3-D RGB space.
Inverse(S) is the inverse of covariance matrix S.

Fig 2: original image

Fig 3: Image segmented with 4 clusters using Mahalanobis Distance

A. Euclidean Distance:

The Euclidean distance is the straight-line distance between two pixels.
Euclidean distance = $\sqrt{((x1 - x2)^2 + (y1 - y2)^2)}$,
where (x1,y1) & (x2,y2) are two pixel points or two data points.
How the function Mahalano2( ) was used for both Mahalanobis and Euclidean distances ?

The only difference between Mahalanobis and Euclidean distance is that Mahalanobis considers the Inverse of the covariance matrix of the set of data points in the 3-d space.
So,
Mahalanobis distance = (P – Q) * INV(Cov(S)) * (P – Q)'
Euclidean distance = (P – Q) * (P – Q)'
Here P is a data point and Q is the center of a cluster.
S is a vector containing all the data points the 3-d color space.

Fig. 4: Image segmented with 4 clusters using Euclidean Distance.

VI. Conclusion

The image segmentation is done using k-means clustering in 3-D RGB space, so it works perfectly fine with all images. The clarity in the segmented image is very good compared to other segmentation techniques. The clarity of the image also depends on the number of clusters used. One disadvantage of the procedure used is that the number of clusters is to be defined in each iteration. The results are compared using both Mahalanobis and Euclidean distance. As one can see from the above image in the previous page that the image segmented with Mahalanobis distance did come better than Euclidean Distance when the image is segmented with 4 clusters. That has to be true because the Mahalanobis distance considers the variances also.

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