Perceptual Color Image Segmentation through K-Means

E.MADHURI¹ Dr.SANDEEP.V.M²
ECE Dept., JPNCE, Mahabubnagar, Andhra Pradesh¹
HOD & Prof., ECE Dept., JPNCE, Mahabubnagar, Andhra Pradesh²

ABSTRACT
Image segmentation refers to partitioning of an image into meaningful regions. Color image segmentation is an important task for computer vision. Generally there is no unique method for segmentation. Clustering is a powerful technique in image segmentation. The cluster analysis is to partition an image data set into number of clusters. In this paper presents k-means clustering method to segment a color image into perceptual partitions.

Keywords: Segmentation, HVS, Clustering, K-Means, Pixel.

1. INTRODUCTION
Image segmentation was, is and will be a major research topic for many image processing researchers. The reasons are obvious and applications endless: most computer vision and image analysis problem require a segmentation stage in order to detect objects or divide the image into regions which can be considered homogeneous according to a given criterion, such as color, motion, texture etc[3]. Clustering is a technique to partition the data into distinct groups in the feature space. The clustering task separates the data into number of partitions. That is volumes in the n-dimensional feature space. These partitions define a hard limit between the different groups and depend on the functions used to model the data distribution.

There are many methods of clustering developed for a wide variety of purposes. K-means is the clustering algorithm used to determine the natural spectral groupings present in a data set [2][5][10]. As k-means approach is iterative, it is computationally intensive and hence applied only to image sub areas rather than to full scenes and can be treated as unsupervised training areas [6].

2. BACK GROUND
The object recognition process constitutes of various phases: Image acquisition, segmentation, feature-extraction and recognition. Segmentation phase is an important activity in the process whose accuracy consists the overall efficiency of the recognition process. The easiest way to achieve a better efficiency is to follow the natural process adopted by the humans, the Human Vision System. Color difference between the object and rest of the image is one of the key features HVS uses in segmenting out the object of interest from the rest of the image. This makes the color information available in the image, an important feature for computer vision. The color information can be made available in a variety of ways. This section surveys the different color models and their pros and cons for the object recognition process.

2.1 RGB:
This is a 3-D color space and any color is given an s combination of red, green and blue colors with appropriate intensities. This space is machine friendly for image acquisition and display of color images. But for analyzing and processing the image perceptually in this domain is complicated. High uncorrelated features of this domain force one to computurily use all the 3 components-red, green and blue, simultaneously making the process to have higher time and space complexities.

2.2 CIELAB:
In an attempt to make perceptual image processing less costly, CIE come out with a color space L a* b*[1][4][8]. In this domain, feature a* represents redness-greenness, b* for yellowness-blueness and L is the intensity component. This allows the color information to be compressed to 2 features, there by the complexities can be reduced.

2.3 HSV:
This color space condenses the whole color information into 2 features-hue and saturation. The third component is the value that presents the intensity. Here feature represents the pure color and saturation gives how much white is added to the pure color [7][9]. The Human Vision System (HVS) uses hue on the primary source of visual information for distinguishing between object in this scene. This allows one to use only the hue feature for processing in most of the perceptual segmentation phase, making time and space complexities of the segmentation very low.

3 PROPOSED METHOD
Color information in RGB format is incomplete process to all 3 color planes is not used. Using all 3 planes is very complicated task. Hyperplane in 3 dimensional space has to be determined for segmentation. It would be easier, if all color information is available in single plane. This initiates one to use the HSI model.

3.1 HSI
The ultimate goal of any segmentation process is to simulate the Human Vision System

1312 | P a g e
The HVS is an excellent system that perceives pseudo-homogeneous (correlated) partitions in spite of non-homogeneity. The main reason for this behavior is the knowledge bank built up by the HVS from the past experiences. It is still hidden from the researchers regarding how the knowledge bank is built and used by the human brain. Typically the raw image data are provided in RGB color space which is perceptually a non-uniform space. By perceptually uniform we mean the equal perceptual difference between colors does correspond to equal distance in the color space. RGB space is suitable for the electronic displays but is not appreciated by the HVS.

In order to compress all the chromatic information in a single stimulus, the researchers found that the HSI (Hue, Saturation, and Intensity) color space comes to aid. Here the different value of hue express the different colors perceived while the saturation gives the amount of dilution added to a pure color and the intensity gives the achromatic information of all color. The hue is defined using both $a^*$ & $b^*$ together:

$$H=\arctan\left(\frac{a^*}{b^*}\right)$$

The saturation is given by:

$$s=\sqrt{(a^*)^2+(b^*)^2}$$

Figure shows the relation between the CIELAB, HSI color space with the color processing by the HVS through the 3 types of cones (L, M & S) present in the retina. With the HSI space, when the image is to be segmented on perceptual basis, most of the times only the hue information will suffice. This makes this color space more useful in economizing the space & time complexities of the segmentation algorithm.

3.2 K-means

Most of the cases the object of interest differs form rest of the image only in color. Hence it is beneficial to segment the image on the basis Hue.HSI model is more nearer to human presumption. RGB model is good for displays. Most of times image contains one object of interest, necessitating us to segment image into 2 partitions. One partition containing object of interest. Let us call it as foreground, and the other contains rest of the image i.e. background. When the distribution of the color information in the image is clustered, K-means method is a better choice for the segmentation. When the image contains more than one object of interest with different color properties, K-means is used to segment it. K-means clustering algorithm can be extended for multiple clusters.

3.2.1 K-means Algorithm

1. Decide the number of partition $k$ & initialize mean for $k$ partition.
2. For every point in image
   a) Find the partition nearest to the point
   b) Add the point of to the partition
   c) Update mean
3. Repeat step 2 till reaches equilibrium.

4. PERFORMANCE EVALUATIONS:

This proposed method has been used to segment an image into number of partitions based on the k-means. The proposed algorithm was applied to the below images i.e. For fig2 & fig3. Results obtained for 4 clusters. So, image can be segmented into 4 partitions. Here first image shows original, second hue and followed by 4 partitions.

Figure 1: Relation of color spaces with Human Vision System

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Figure 2: segmentation of a natural mage:
   Top row: Original, Hue, One partition
   Bottom row: Other three partitions

Figure 3: segmentation of a natural image
   First image shows Original, Second shows its hue and followed by 4 partitions.

   The original image is in the form of pixels and it is converted into a feature space (HSI). The similar points i.e. the points which have
similar color are grouped together using k-means clustering method. At each partition it displays an image which has similar color, i.e. clearly shown in above.

5 CONCLUSIONS:

The image segmentation is done using k-means clustering. So it works perfectly fine with all images. The clarity in the segmented image is good. Compared to other segmentation techniques. The clarity of the image depends on the number of clusters used. The k-means method is numerical, unsupervised, nondeterministic and iterative. For small number of k, k-mean computation is faster.

Higher time complexity of the k-means techniques is a drawback. This technique uses only the color feature for segmentation and spatial correlation is not used this work is in progress to reduce the time complexity and includes spatial correlation through the image of deformable models.

REFERENCES:


Author information:

1.E.Madhuri Pursuing M.Tech(DSCE) from JayaPrakash Narayana College of Engineering Currently she is working as Assistant Professor at Jayaprakash narayan college of engineering And has 2 years of Experience in teaching. Her areas of interest include.Image Processing, wireless networks, signal processing

2. Dr. Sandeep V.M. completed Ph.D in Faculty of Electrical and Electronics Engineering, Sciences, from Visveswaraiah Technological University, Belgaum, and M.Tech from Gulbarga University and B.Tech from Gulbarga University. His research interests are in the areas of Signal and Image Processing, Pattern Recognition, Communication, Electromagnetics. He is Reviewer for Pattern Recognition Letters (PRL). He acted as Reviewer for many International Conferences.He has 24 years of teaching experience. He is member of LMIST – Life Member Instrument Society of India (IISc, Bangalore). And he guided more than 100 projects at UG level and 35 at PG level. And published more than 10 papers in international journals and 9 Conference Proceedings