International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 3 Issue 3, March 2014

Segmentation of Natural Color Images in HSI Color Space Based on FCM Clustering

Ganesan P, Priya Chakravarty, Shweta Verma

Abstract— **Image segmentation is a process that divides an image into several images according to its gray level, color, texture, shape or other features. Segmentation subdivides an image into constituent regions or objects. It is a basic technology in the area of image processing and computer vision. It is an important and challenging problem and a necessary first step in image analysis as well as in high-level image interpretation and understanding such as robotics vision, object recognition, and bio-medical imaging. In this paper FCM (fuzzy c means clustering) based segmentation of natural image is compared with the HSI color space of natural images and conclusion is drawn on the basis of comparison There are various methods used for the segmentation of natural images, but fuzzy based approaches are most popular and widely used because they have a good performance in a large class of images.**

Index Terms— **clustering, color space, FCM, image segmentation, HSI color space RGB color space.**

I. Introduction

In the image segmentation process, an image is divided into different clusters or regions. These regions have a strong correlation with the objects in the image. The quality of segmentation is the basis for the success of an image analysis process. Image segmentation refers to a process by which a raw input image is partitioned into non-overlapping regions such that each region is homogenous and connected, and the union of not more than two spatially adjacent regions is homogeneous. Image segmentation is an important process in most medical image analysis tasks. An image segmentation algorithm decomposes an image into regions having visual similarity and strong statistical correlation. Extraction and classification of cervical cells is an important process that has many applications in medical imaging. A good segmentation algorithm will benefit clinicians and patients as they provide important information for 3-D visualization, surgical planning and early disease detection. Segmentation refers to the process of dividing a digital image into multiple segment set of pixels, also known as super pixels. The main aim of segmentation is to simplify and change the representation of an image into meaningful image that is more appropriate and easier to analyze. Segmentation is a collection of methods that allowing spatially partitioning close parts of the image as objects.

Manuscript received Feb, 2014.
Ganesan P*, Research Scholar: Electronics &Control Engg; Sathyabama University,Chennai,India,9884161831*
Priya chakravarty*, Electronics &Control Engg; Sathyabama University ,Chennai, India, 8148897283*
Shweta Verma*, Electronics &Control Engg; Sathyabama University, Chennai, India, 7305335110*

II. Color Space

A color model is an orderly system for creating a whole range of colors from a small set of primary colors. There are two types of color models that are subtractive and additive. Additive color models use light to display color while subtractive models use printing inks. Colors perceived in additive models are the result of transmitted light. Colors perceived in subtractive models are the result of reflected light. Each color model has its own gamut (range) of colors that can be displayed or printed. Each color model is limited to only a portion of the visible spectrum. Since a color model has a particular range of available color or gamut, it is referred to as using a "color space". Color space is a mathematical representation of a set of colors. There are five major models that sub-divide into others, which are: CIELAB, RGB, YCbCr, CYMK, HSI color spaces.

A. RGB Color space

The red, green, and blue (RGB) color space is widely used throughout computer applications. Green, Red and blue are three primary additive colors (individual components are added together to form a desired color) and are rep-resented by a three-dimensional, Cartesian coordinate system. The RGB color space is the most prevalent choice for computer graphics because color displays use blue, green, and red to create the desired color. The choice of the RGB color space simplifies the architecture and system design. A system that is designed using the RGB color space can take advantage of a large number of existing soft-ware routines, since this color has been around for a number of years. Besides these there are various limitations of RGB color space that is why it should be converted into other color spaces.

The RGB model forms its gamut from the primary additive colors of red, green and blue. When green, red and blue is combined it forms white. Computers usually display RGB using 24-bit color. In the 24-bit RGB color space, there are 256 variations for each of the additive colors of green, red and blue. Therefore there are 16,777,216 possible colors (256 reds x 256 greens x 256 blues) in the 24-bit RGB color space. In the RGB color space, colors are represented by varying intensities of blue, green and red light. The intensity of each of the blue, green and red components can be represented on a scale from 0 to 255 with 0 being the least intensity (no light emitted) to 255(maximum intensity).

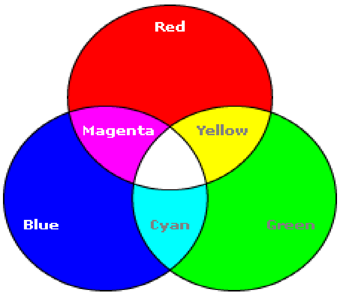


Figure-1 RGB color space

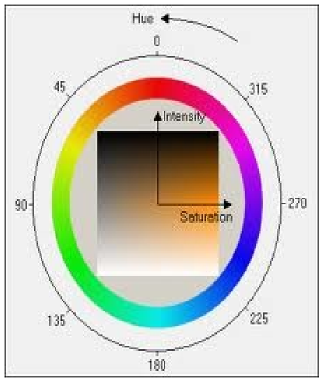


Figure-2 HSI color space

B. HSI Color Space

The HSI (hue, saturation, intensity) color spaces were developed to be more efficient in manipulating color and were designed to approximate the way of human vision and interpret color. They were developed when colors was specified manually. HSI (hue, saturation, intensity) is similar to HSV (hue saturation, value) the term value is used rather than intensity. The difference between HSV and HSI is the calculation of the brightness component (I or V), which determines the distribution and dynamic range of both the brightness (I or V) and saturation (S). The HSI color space is best for traditional image processing functions such as equalization, histograms, convolution etc, which operate by manipulation of the brightness values since I is equally dependent on R, G, and B. The HSI color space is preferred for manipulation of hue and saturation (to shift colors or adjust the amount of color) since it yields a greater dynamic range of saturation. I denotes the light intensity, H denotes the hue that indicates the measure of the color purity, S is the saturation (the degree of a color permeated the white color). The perception of color and our way of talking about it in everyday life is not well served by the RGB color space. Hue is defined as an angle in the range [0,2π] relative to the Red axis with red at angle 0, blue at 4π/3, green at 2π/3, and red again at 2π. Saturation is the depth or purity of the color and is measured as a radial distance from the central axis with value between 0 at the center to 1 at the outer surface. HSI is one of many color spaces that separate color from intensity. HSI is often used simply because the code for converting between RGB and HSI is widely available and can also be easily implemented. The HSI color space is a device-dependent color space, it means that the actual color that we see on your monitor depends on what kind of monitor we are using, and what its settings are.

• Hue: It is quality by which we distinguish one color family from another, as green from blue or purple or red from yellow.

• Chroma [Saturation in HSI]: It is that quality of color by which we distinguish a strong color from a weak one; the degree of departure of a color sensation from that of a white or gray; the intensity of a distinctive hue; color intensity."

• Intensity: It is that quality of color that distinguish light color from a dark color

The transformation of an image in RGB color space to HSL color space is given as follows

$$H = arccos \frac{\frac{1}{2}(2R-G-B)}{\sqrt{(R-G)^2-(R-B)(G-B)}} \quad (1)$$

$$L = \frac{\max(R,G,B)+\min(R,G,B)}{2} \quad (2)$$

$$S = \left\{\frac{\max(R,G,B)-\min(R,G,B)}{\max(R,G,B)+\min(R,G,B)} \quad for\ L < 0.5 \right. \quad (3)$$

$$S = \left\{\frac{\max(R,G,B)-\min(R,G,B)}{2-\max(R,G,B)-\min(R,G,B)} \quad for\ L \geq 0.5 \right. \quad (4)$$

III. CLUSTERING

.

Clustering is a process for classifying objects or patterns in such a way that samples of the same group are more similar to one another than samples belonging to different groups. Many clustering techniques have been used, such as the hard clustering method and the fuzzy clustering method, each of which has its own special characteristics. Hard clustering methods are based on classical set theory, and require that an object either does or does not belong to a cluster. Hard clustering means partitioning the data into a specified number of mutually exclusive subsets. Fuzzy clustering methods allow the objects to belong to several clusters simultaneously, with different degrees of membership. In many situations, fuzzy clustering is more natural than hard clustering. Objects on the boundaries between several classes are not forced to fully belong to one of the classes, but rather are assigned membership degrees between 0 and 1 indicating their partial membership. The conventional hard clustering method restricts each point of the data set to only one cluster. As a result, of this approach the segmentation results are often very crisp i.e., each pixel of the image belongs to just one class. However, in many situations, for images, issues such as poor contrast, limited spatial resolution, overlapping intensity, noise and intensities in homogeneities variation make this hard (crisp) segmentation a difficult task. Clustering can be termed here as a grouping of similar images in the database. Clustering is done based on different characteristics of an image such as size, texture, color etc. The objective of clustering is to get desirable result, fast retrieval and effective storage in various areas.

Two most important benefits of clustering are as follows:

1. Easy tackling of noisy data and outliers,

2. Ability to deal with the data having various types of variables, such as continuous variable that requires standardized data, binary variable, nominal variable (a more generalized representation of binary variable), ordinal variable (where order of data is the most important criterion) and mixed variables

A. Fuzzy C-Means Clustering

Fuzzy C-means (FCM) algorithm, one of the most popular fuzzy clustering techniques, was originally proposed by Dunn and had been modified by Bezdek. FCM is able to determine, and in turn, iteratively update the membership values of a data point with the pre-defined number of clusters. This algorithm works by assigning membership to each data point corresponding to each cluster center on the basis of distance between the cluster center and the data point. More the data is near to the cluster center more is its membership towards the particular cluster center. Clearly, summation of membership of each data point should be equal to one. After each iteration membership and cluster centers are updated according to the formula

$$\mu ij = 1/\sum_{k=1}^{c}(dij/dik)^{(2/m-1)} \quad (1)$$

$$vj = (\sum_{i=1}^{n}(\mu ij)^m \; xi)/(\sum_{i=1}^{n}(\mu ij)^m)\;, \forall j = 1,2,\ldots\ldots c \quad (2)$$

Where n is the number of data points.

v_j represents the cluster center.

m is the fuzziness index m €[1,∞].

c represents the number of cluster center.

μ_{ij} represents the membershipi^{th} cluster center of data to j^{th} cluster center.

d_{ij} represents the Euclidean distance between i^{th} data and j^{th} cluster center.

Main objective of fuzzy c-means algorithm is to minimize its objective function:

$$J(U,V) = \sum_{i=1}^{n}\sum_{j=1}^{c}(\mu ij)^m \;\|xi - vj\|^2 \quad (3)$$

where, $||x_i - v_j||$ is the Euclidean distance between i^{th} data and j^{th} cluster center.

B. Algorithm for Fuzzy C-Means Clustering

Let X = {x_1, x_2, x_3 ..., x_n} be the set of data points and V = {v_1, v_2, v_3 ..., v_c} be the set of centers.

1) Randomly select *'c'* cluster centers.

2) Calculate the fuzzy membership μ_{ij} using:

$$\mu ij = 1/\sum_{k=1}^{c}(dij/dik)^{(2/m-1)} \quad (4)$$

3) Compute the fuzzy centers v_j using:

$$vj = (\sum_{i=1}^{n}(\mu ij)^m \; xi)/(\sum_{i=1}^{n}(\mu ij)^m)\;, \forall j = 1,2,\ldots\ldots c \quad (5)$$

4) Repeat step 2) and 3) until the minimum J value is achieved or $\|U^{(K+1)} - U^K\| < \beta$

where k is the iteration step.
β is the termination criterion between [0, 1].
U= μ_{ij} is the fuzzy membership matrix.
J is the objective function.

C. Features of Fuzzy C-Means Clustering

1) Gives best result for overlapped data set and comparatively better then k-means algorithm.

2) Unlike k-means where data point must exclusively belong to one cluster center here data point is assigned membership to each cluster center as a result of which data point may belong to more than one cluster center.

3) FCM algorithm has additional flexibility for the pixels to belong to multiple classes with varying degrees of membership.

4) Disadvantage of FCM (fuzzy c means clustering) is time consuming which is overcome by improved FCM.

IV. PROPOSED METHOD

The figure shows the proposed method for the segmentation of natural images by using fuzzy c means clustering (FCM). To test the efficiency of the proposed approach, a data base of 50 images was created. All the images were collected from internet which has a huge collection of natural images. Initially the input natural image is sharpened for the purpose of sharpening the edges and minutes the important details in the image. Then the sharpened image is transformed into HSI color space. The image in this color space has three different channels as hue, saturation and lightness. The transformed image is then segmented by using fuzzy c means clustering algorithm. Fuzzy clustering is the most popular unsupervised learning. After applying the fuzzy c means clustering technique segmented image is obtained as output.

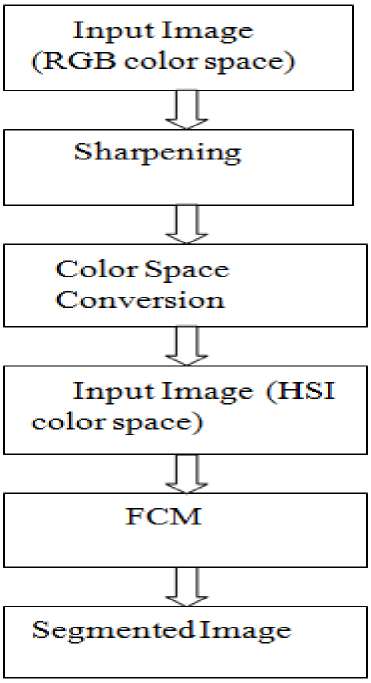


Figure-3 the proposed method

A. Performance analysis

On the basis of execution time and peak signal to noise ratio (PSNR) the comparison has been done.

(a)Peak Signal to Noise ratio (PSNR)

In order to evaluate the performance of different Segmentation methods, image quality measurement is required and known as the peak signal-to-noise ratio (PSNR). The Mean absolute Error (MAE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics frequently used to compare the quality of image. PSNR in decibels (dB) is computed by using

PSNR = 20 log 10 (255^2 / MAE).

(b)Convergence rate or Execution time

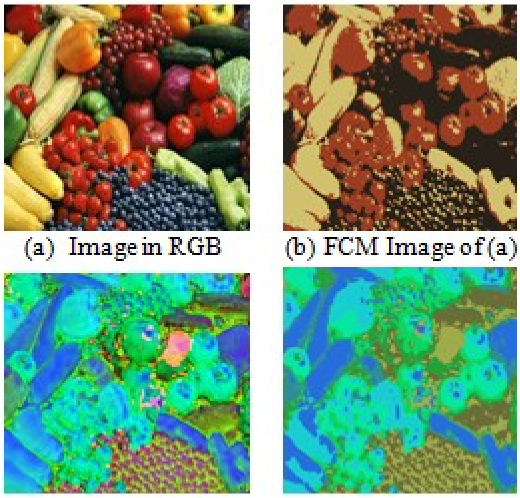
Convergence rate is defined as the time period required for the system to reach the stabilized condition. The lesser the execution time better is the clustering technique.

(c)Mean absolute error (MAE):

Mean absolute error is the average of the difference between predicted and actual value in all test cases; it is the average prediction error. MAE indicates that higher the values of MAE mean the image is of poor quality.

$$MSE = 1/mn \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

Where, I represent the matrix data of our original image.
K represent the matrix data of our degraded image
m represent the numbers of rows of pixels of the images and i represent the index of that row.
n represent the number of columns of pixels of the image and j represent the index of that column

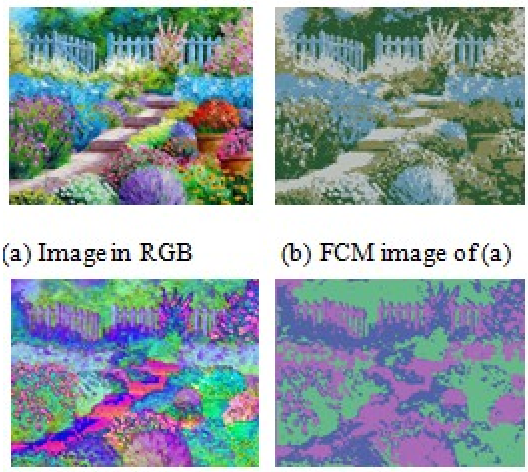


(a) Image in RGB (b) FCM Image of (a)
(c) Image in HSI (d) FCM image of (c)

Figure-4 segmentation result for image 1 using proposed method

TABLE-I Segmentation result for image 1 in RGB and HSI Color Space

Image name	No. of cluster	No. of iteration	Execution time	PSNR
1.jpg	3	11	71.8245	25.8697
1hsi.jpg	5	15	174.7709	33.961



(a) Image in RGB (b) FCM image of (a)
(c) Image in RGB (d) FCM image of (c)

Figure-5 segmentation result for image 2 using proposed method

TABLE-II Segmentation result for image 2 in RGB and HSI Color Space

Image name	No. of cluster	No. of iteration	Execution time	PSNR
2.jpg	4	15	126.6525	24.1934
2hsi.jpg	3	15	84.851	22.9475

The comparison has been done by considering PSNR and execution time factor. As we can see from the table that execution time for HSI color space is less than that of RGB color space. Also the PSNR value of HSI color space is more for HIS color space. It is observed that Fuzzy C-Means (FCM) algorithm proved to be superior over the other clustering approaches in terms of execution time and PSNR. But the major drawback of the FCM algorithm is the huge computational time required for execution. The efficiency of the FCM algorithm in terms of computational rate is improved by modifying the cluster center. This drawback can be overcome by the improved fuzzy c means clustering.

V. CONCLUSION

In this paper, a new method for the segmentation of the natural images based on the fuzzy c-means clustering is proposed. Even though number of images are tested using the proposed method, the result of only one image is illustrated and explained in this article. In this color based segmentation, natural images are segmented in both RGB and HSI color space. The result of the segmentation process in the RGB and HSI color space is compared using a group of image quality measures such as execution time and PSNR ratio. To test the efficiency of the proposed approach the HSI based detection is best suited for simple images with uniform background. Moreover, if there is a lot of fluctuation in the value of the color information (hue and saturation), pixels with small and large intensities are not considered. The experimental results shows that the proposed algorithms yields segmented gray scale image of perfect accuracy and the required compute time reasonable and also reveal the improved fuzzy c means achieve better segmentation compare to others. The advantages of the new method are the following: (1) it yields regions more homogeneous than those of other methods, (2) it removes noisy spots, and (3) it is less sensitive to noise than other techniques. This technique is a powerful method for noisy image segmentation and works for both single and multiple-feature data with spatial information. For the applications like video conferencing, real-time tracking the proposed algorithm can be used. Our experimental results show that the proposed algorithm can be used in real-time applications. Additionally it has the advantage of being insensitive to small variations of face regions.

REFERENCES

[1] Nikhil R. Pal., Kuhu Pal; and James C, Bezdek, " A Possibilistic Fuzzy C Means clustering algorithm", IEEE transactions of fuzzy systems, vol. 13, no. 4, August 2005, pp. 517- 530.

[2] Ganesan, P., and V. Rajini. "A method to segment color images based on modified fuzzy-possibilistic-c-means clustering algorithm." Recent Advances in Space Technology Services and Climate Change (RSTSCC), 2010. IEEE, 2010.

[3] Christian Correa et. al, "A Comparison of fuzzy clustering algorithms applied to feature extraction on vineyard", Lecture Notes in Computer Science, Springer, 2012.

[4] Ganesan, P., and V. Rajini. "A method to segment color images based on modified fuzzy-possibilistic-c-means clustering algorithm." Recent Advances in Space Technology Services and Climate Change (RSTSCC), 2010. IEEE, 2010.

[5] R. Krishnapuram and J. Keller, "The possibilistic c means algorithm : Insights and recommendations",IEEE Trans. Fuzzy Syst., vol. 1, no. 2, pp. 98–110, Apr. 1993pp. 385–393, Jun. 1996.

[6] Zhengjian Ding, Jin Sun, and Yang Zang, "FCM Image Segmentation algorithm based on color space and spatial information", International journal on computer and communication,Vol 2,No 1,2013

[7] X.Li, X.Lu, J.Tian," Application of fuzzy c-means clustering in data analysis of metabolomics", Analytical chemistry, Vol 80, no.11, pp. 4468-4475, 2009.

[8] Jiang- She Zhang and Yiu- Wing Leung., "Improved possibilistic c means clustering algorithm", IEEE transactins on fuzzy systems, vol. 12, no. 2, april 2004,pp. 209-218.

[9] Hamed Shamsi and Hadi Seyadarabi, " A Modified Fuzzy C-Means Clustering with Spatial Information for Image Segmentation", International Journal of Computer Theory and Engineering, Vol. 4, No. 5, October 2012, 762-766

[10] B.Sathya R.Manavalan Image Segmentation by Clustering Methods: Performance Analysis International Journal of Computer Applications (0975 – 8887) Volume 29– No.11, September 2011.

[11] Dr.G.Padmavathi, Mr.M.Muthukumar Mr. Suresh Kumar Thakur Non linear Image segmentation using fuzzy c means clustering method with thresholding for underwater images

[12] Ritu Agrawal,Prof. Manisha Sharma Comparison and Analysis of Fuzzy Clustering Technique for Color Image Segmentation in terms of PSNR and Accuracy International Journal of Advanced Research in Computer Science Volume 2, No. 6, Nov-Dec 2011

[13] http://learn.colorotate.org/color-models.html

[14] www.equqsys.de

[15] http://www.mathworks.com

Ganesan P is working as Assistant Professor in the department of Electronics and Control Engineering in Sathyabama University, Chennai, Tamilnadu, India. He has received his B.E degree from Madurai Kamaraj University, M.E., Degree from Sathyabama University. He is pursuing the Ph.D. degree in the area of image processing. His areas of interest include image and video processing, and computer vision

Priyachakravarty is pursuing B.E degree in the department of Electronics and Control Engineering from Sathyabama University, Chennai, Tamilnadu, India. Her areas of interest include image and video processing, and computer vision.

Shweta Verma is pursuing B.E degree in the department of Electronics and Control Engineering from Sathyabama University, Chennai, Tamilnadu, India. Her areas of interest include image and video processing, and computer vision.

