International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-3 Issue-9, February 2014

Color Image Segmentation Using K-Means Clustering and Otsu's Adaptive Thresholding

Vijay Jumb, Mandar Sohani, Avinash Shrivas

Abstract— In this paper, an approach for color image segmentation is presented. In this method foreground objects are distinguished clearly from the background. As the HSV color space is similar to the way human eyes perceive color, hence in this method, first RGB image is converted to HSV (Hue, Saturation, Value) color model and V (Value) channel is extracted, as Value corresponds directly to the concept of intensity/brightness in the color basics section. Next an Otsu's multi-thresholding is applied on V channel to get the best thresholds from the image. The result of Otsu's multi-thresholding may consist of over segmented regions, hence K-means clustering is applied to merge the over segmented regions. Finally background subtraction is done along with morphological processing. This proposed system is applied on Berkley segmentation database. The proposed method is compared with three different types of segmentation algorithms that ensure accuracy and quality of different types of color images. The experimental results are obtained using metrics such as PSNR and MSE, which proves the proposed algorithm, produces better results as compared to other algorithms.

Index Terms— Color image segmentation, HSV color space, Otsu's multi-thresholding, K-means clustering, morphological processing, PSNR and MSE.

I. INTRODUCTION

Image segmentation is an important process in many computer vision and image processing applications, since people are interested in certain parts of the image. It divides an image into a number of discrete regions such that the pixels have high similarity in each region and high contrast between regions. Properties like gray-level, color, intensity, texture, depth or motion help to recognize similar regions and similarity of such properties, is used to construct groups of regions having a specific meaning. Segmentation is a valuable tool in many fields including industry, health care, image processing, remote sensing, traffic image, content based image, pattern recognition, video and computer vision etc. A particular type of image segmentation method can be found in application involving the detection, recognition, and measurement of objects in an image. Till now many researches have focused on gray-level image segmentation, whereas we know that color images carry most of the information.

Manuscript published on 30 January 2014.
*****Correspondence Author(s)
Vijay Jumb, Lecturer, Computer Department, Xavier Institute of Engineering, Mumbai, India.
Prof. Mandar Sohani, Associate Professor, Computer Department, Vidyalankar Institute of Technology, Mumbai, India.
Prof. Avinash Shrivas, Assistant Professor, Computer Department, Vidyalankar Institute of Technology, Mumbai, India.

Segmentation techniques can be classified [1] into the following categories: Edge-based, Threshold based, Region-based, Neural Network based, Cluster-based, and Hybrid.
Image segmentation based on thresholding is one of the oldest and powerful technique, since the threshold value divides the pixels in such a way that pixels having intensity value les than threshold belongs to one class while pixels whose intensity value is greater than threshold belongs to another class [3]. Segmentation based on edge detection attempts to resolve image by detecting the edges between different regions that have sudden change in intensity value are extracted and linked to form closed region boundaries. Region based methods [4], divides an image into different regions that are similar according to a set of some predefined conditions. The Neural Network based image segmentation techniques reported in the literature [5] can mainly be classified into two categories: supervised and unsupervised methods. Supervised methods require expert human input for segmentation. Usually this means that human experts are carefully selecting the training data that is then used to segment the images. Unsupervised methods are semi or fully automatic. User intervention might be necessary at some point in the process to improve performance of the methods, but the results should be more or less human independent. An unsupervised segmentation method automatically partitions the images without operator intervention. However, these architectures might be implemented using application specific a priori knowledge at design time, i.e. anatomical, physical or biological knowledge. Clustering is an unsupervised learning technique, where one needs to know the number of clusters in advance to classify pixels [6]. A similarity condition is defined between pixels, and then similar pixels are grouped together to form clusters.
Though, various algorithms have offered to segment color images, but no one could work well for different kinds of images. The proposed method is applied to different kinds of images for color image segmentation. The results of the proposed method are compared with different segmentation algorithms like Fuzzy C-Means (FCM), Region Growing (RG), and Hill-climbing with K-Means (HKM) algorithms with respect to PSNR (Peak Signal to Noise Ratio) and MSE (Mean square Error) metrics [7].

II. PROPOSED SYSTEM

Step 1: We consider the RGB image as an input for this system. The RGB image is converted to HSV color space.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Figure 1: RGB image to HSV color space

Step 2: The V channel of HSV color space is extracted.

Figure 2: Extracted V channel of HSV color space

Step 3: Now we initialize Separation Factor (SF=0) and N=2, where N implies number of classes. The Separation Factor plays an important role in segmenting an image using Otsu's thresholding. The value of SF lies between 0 and 1. The higher value of SF implies that image has been segmented absolutely.

Step 4: Now Otsu's thresholding [8] is applied on V channel of HSV color space. Otsu proposed the concept of maximum classes' variance method. The Otsu's method is greatly used to segment the image for the reason being simple calculation, less time consuming and effective. This method segments the image by automatically selecting the threshold value based on largest inter-class variance between target and background. Otsu method selects the optimal threshold t by maximizing the between-class variance (σ_B^2), which is same as minimizing the within-class variance (σ_W^2), as the total variance ($\sigma_B^2 + \sigma_W^2 = \sigma^2$) which is sum of the within-class variance and the between class variance, remains constant for given image.

Step 5: The Otsu's method determines the value of SF which is defined as σ_B^2 / σ^2. If the value of SF tends to 1, then we can say that image is segmented otherwise the number of classes is increased by 1 i.e. N=N+1, and again Otsu's thresholding is applied with this new value of N.

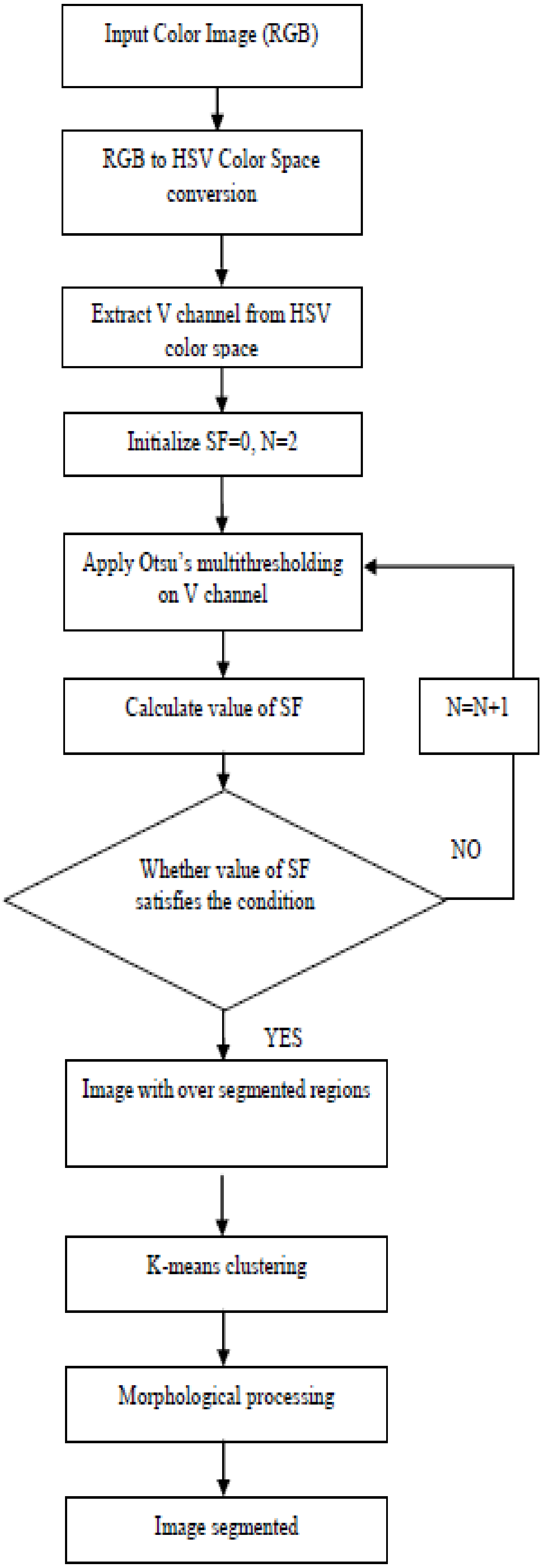


Figure 3: Flowchart of proposed system

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Figure 4: Otsu's multi-thresholding on V channel

Step 6: The output of Otsu's thresholding may lead to over segmentation. Hence we need some technique to merge the over segmented regions. We use K-means clustering, which is partitioning method for grouping objects so that within-group variance is minimized. This method works as follows:

a. Initialize two class centers randomly; these centers represent initial group centroids.
b. Calculate the value of histogram bin value distance between each image pixel and class centroids; assign each image pixel to its nearest class centroid.
c. Recalculate the new positions of centroids by calculating the mean histogram bin value of the same group.
d. Repeat steps b and c till the value of centroids changes.

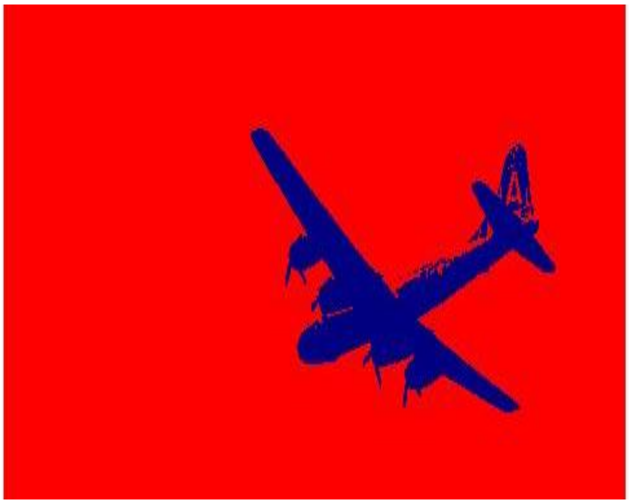


Figure 5: K-means clustering

Step 7: The output of K-means clustering may consists of small holes within the detected object. Hence to smooth it, to give it uniform appearance we apply morphological processing to fill up small holes and finally we get the segmented image.

Figure 6: Morphological Processing and Background Subtraction

III. SEGMENTATION EVALUATION INDEX: PSNR AND MSE

In this section, we have compared the proposed system with three different segmentation algorithms which are: Fuzzy C-Means clustering (FCM), Region Growing (RG), and Hill-climbing with K-means (HKM) algorithms for color image segmentation [15]. The authors in [9] have proposed a method for color based Image segmentation using Fuzzy C-Means Clustering and L*a*b* color space. The authors in [10], have proposed a color image segmentation method of automatic seed region growing along with watershed algorithm which was based on the traditional seed region growing algorithm. The authors in [11], have proposed Hill climbing with FCM Based Human Skin Region Detection using Bayes Rule.

We use PSNR to calculate the peak signal-to-noise ratio, between two images. In [12], the authors presented PSNR and MSE to evaluate the segmentation performance. There are various performance measures metrics for examining image quality, such as visually significant blocking artifact metric (VSBAM), Structural Similarity Index Metric (SSIM) [13].

A. Peak Signal to Noise Ratio (PSNR)

The PSNR is calculated based on color texture based image segmentation by using the **Eq.1**. The PSNR range between [0, 1), the higher is better .

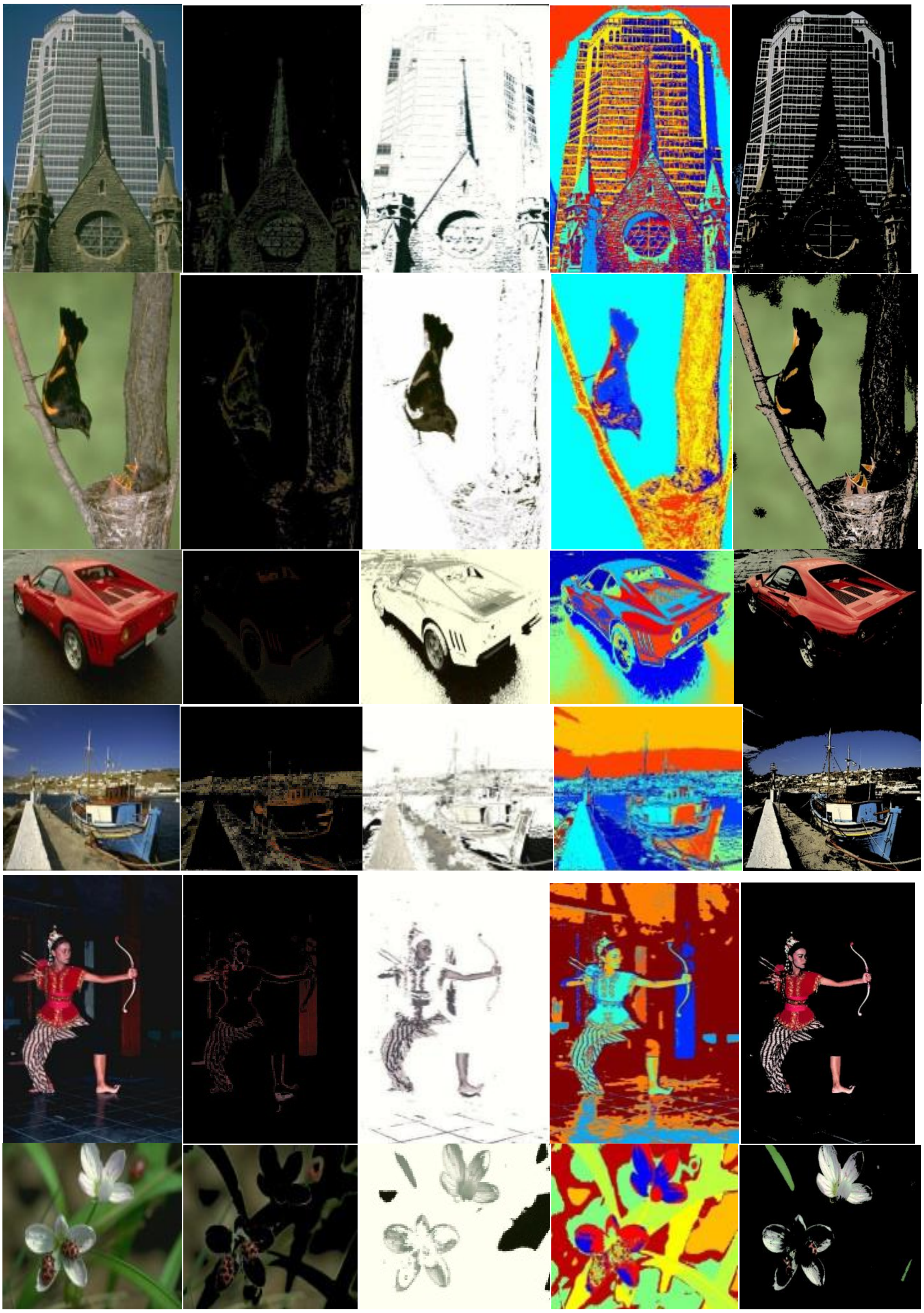
$$PSNR(I,S) = \frac{10\log 10 s^2}{MSE(I,S)}$$

(1) In above equation, s is the maximum fluctuation in the input image data type i.e. 255.

B. Mean Square Error (MSE)

Mean Square Error (MSE) is calculated pixel-by pixel by adding up the squared difference of all the pixels and dividing by the total pixel count. MSE of the segmented image can be calculated by using the **Eq. 2**. The MSE range between [0, 1], the lower is better.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)



(Original) (FCM) (RG) (HKM) (Proposed Method)

Figure 7: Comparison of the FCM, RG, HKM and Proposed Method

$$MSE(I,S)=\frac{(\sum_{i=0}\sum_{j=0}[I(i,j)-S(i,j)]^2)}{MN} \quad (2)$$

Here M and N are the number of rows and columns in the input images, respectively, whereas I and S are the original and segmented image.

IV. EXPERIMENTAL RESULTS

We have tested the proposed algorithm on Berkeley image database [14] images and compared the experimental results with three different image segmentation algorithms [15]. The size of all the images is 481X321 pixels (or 321X481). In order to facilitate performance comparison of quantitative displays of the results, as in all color images are normalized to the longest side equals to 320 pixels in all experiments. All the algorithms are implemented in MATLAB code and tested on a Intel (R) Core (TM) i5-337U 1.8GHz CPU, 4GB Memory, Windows 8 OS.

We have compared the results of the proposed system with three algorithms which include: Fuzzy C-Means (FCM), Region Growing (RG), and Hill-climbing with K-Means (HKM) algorithms for color image segmentation with 6 different kinds of images as shown in Figure 7.

The 6 different kinds of images are namely “Building”, “Bird”, “Car”, “Beach”, “Lady”, “Flower” (Figure 7). It is clear from the figures that our proposed system performs better than three different segmentation algorithms.

From these quantitative results in TABLE I and II, we can see that our method performs better than the other three methods in terms of most indices. In future research we will focus on a more standard performance measure which could well reflect the difference between segmentation results.

TABLE I. PERFORMANCE COMPARISION OF FOUR ALGORITHMS USING PSNR AND MSE

Image	Metrics (db)	FCM	RG	HKM	proposed
Building	PSNR	56.23	52.26	56.37	57.20
	MSE	0.14	0.39	0.15	0.12
Bird	PSNR	54.48	52.26	54.89	60.18
	MSE	0.23	0.39	0.21	0.06
Car	PSNR	55.32	53.58	55.21	57.15
	MSE	0.19	0.29	0.20	0.12
Beach	PSNR	52.58	52.35	52.20	58.69
	MSE	0.36	0.15	0.39	0.08
Lady	PSNR	60.78	49.46	54.03	60.78
	MSE	0.05	0.74	0.26	0.05
Flower	PSNR	58.10	51.72	53.21	58.69
	MSE	0.08	0.44	0.31	0.13

TABLE II. AVERAGE PERFORMANCE OF FOUR ALGORITHMS USING PSNR AND MSE

Metrics(db)	FCM	RG	HKM	Proposed
PSNR	56.22	51.86	54.17	57.79
MSE	0.17	0.41	0.26	0.10

REFERENCES

1. Rajeshwar Dass, Priyanka, Swapna Devi, “Image Segmentation Techniques”, International Journal on Electronics & Communication Technology (IJECT), Vol. 3, Issue 1, pp. 66-70, Jan. - March 2012.
2. N. R. Pal, S. K. Pal,“A Review on Image Segmentation Techniques”, Pattern Recognition, Vol. 26, No. 9, pp. 1277-1294, 1993.
3. W. X. Kang, Q. Q. Yang, R. R. Liang,“The Comparative Research on Image Segmentation Algorithms”, IEEE Conference on ETCS, pp. 703-707, 2009.
4. H. G. Kaganami, Z. Beij,“Region Based Detection versus Edge Detection”, IEEE Transactions on Intelligent information hiding and multimedia signal processing, pp.1217-1221, 2009.
5. C. Zhu, J. Ni, Y. Li, G. Gu,“General Tendencies in Segmentation of Medical Ultrasound Images”, International Conference on ICICSE, pp. 113-117, 2009.
6. V. K. Dehariya, S. K. Shrivastava, R. C. Jain,“Clustering of Image Data Set Using K-Means and Fuzzy K-Means Algorithms”, International conference on CICN, pp. 386- 391, 2010.
7. Md. Habibur Rahman, Md. Rafiqul Islam, “Segmentation of Color Image using Adaptive Thresholding and Masking with Watershed Algorithm”, IEEE, 2013.
8. N.Otsu, “A threshold selection from gray level histograms”, IEEE Trans. Systems, Man and Cybernetics, vol.9, pp. 62-66. Mar. 1979.
9. T. Saikumar, P. Yugander, P. Murthy and B.Smitha, "Colour Based Image Segmentation Using Fuzzy C-Means Clustering," International Conference on Computer and Software Modeling IPCSIT, IACSIT Press, Vol. 14, 2011.
10. A. Kumar and P. Kumar, "A New Framework for Color Image Segmentation Using Watershed Algorithm," Computer Engineering and Intelligent Systems, Vol. 2(3), pp. 41-46, 2008.
11. R. Vijayanandh, G. Balakrishnan, "Hillclimbing Segmentation with Fuzzy C-Means Based Human Skin Region Detection using Bayes Rule," European Journal of Scientific Research (EJSR), Vol. 76(1), pp.95-107, 2012.
12. C. Mythili and V. Kavitha, "Color Image Segmentat ion using ERKFCM," International Journal of Computer Applications (IJCA), Vol. 41(20), pp. 21-28, 2012.
13. Z. Wang, A. Bovik, H. Sheikh, and E. Simoncelli, “Image quality assessment: from error visibility to structural similarity,” IEEE Trans. IP, Vol. 13, pp. 600-612, 2004.
14. The Berkley Segmentation Database and Benchmark. [online] http://www.eecs.berkley.edu/-Research/Projects/CS/vision/bsds/.
15. Md. Habibur Rahman, Md. Rafiqul Islam, “Segmentation of Color Image using Adaptive Thresholding and Masking with Watershed Algorithm”, IEEE, 2013.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)