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Color Image Segmentation using FCM Clustering Technique in RGB, L*a*b, HSV, YIQ Color spaces

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ABSTRACT

*Image segmentation is the important task for image analysis and understanding it. The segmentation of color image is challenging task in the image analysis process. Segmentation of color images gives more information than gray scale image. This paper performs segmentation of color image in different color spaces, as segmentation of RGB color image not always gives better segmentation results also not more suitable in image analysis and understanding. In this paper the color image is converted into L*a*b, HSV, YIQ color spaces for segmentation. Fuzzy c-means (FCM) clustering is used for the segmentation of color images. FCM clustering gives good results for color image segmentation as it extracts more information from color images. Analysis of the segmented results in RGB, L*a*b, HSV, YIQ color spaces are given in this paper.*

Keywords: Image segmentation, RGB color image, L*a*b color space, HSV color space, YIQ color space, Fuzzy c-means

INTRODUCTION

Image segmentation is the process of dividing images into different segments called region with similar features. A pixel is the main element of an image. The segments of segmented image are groups of similar pixels with some predefined criterion like texture, color, intensity, and gray-level [1]. Filtering noise from an image, medical application, satellite imaging application, Face recognition, Fingerprint recognition, handwritten letter recognition is some of the applications of image segmentation. According to [2-4], color image contain more attributes than grayscale image. Color Image segmentation provides best and easy way to understand and analyze an image. The challenging problems in color image segmentation include two main issues, which color space should be used and which suitable technique should be applied because color image is not suitable for segmentation and analysis. It is difficult to specify a specific number of colors in color image so, segmentation of color image depends on the choice of color space. The common color spaces used for segmentation are RGB (Red, Green, Blue), YIQ, CIE XYZ, HSV (hue, intensity, value). The segmentation of color images includes region based technique, Edge detection techniques, split and merging techniques and clustering techniques as given in [5-7].

The K-means and Fuzzy C-means (FCM) clustering techniques are widely used for color image segmentation. The K-means clustering assign each object to only one cluster and not deal with outliers accurately. Unlike the K-means clustering, FCM clustering gives better segmentation for overlapping clusters and also extract more information compare to other techniques in color images as given in [4, 8-9].

The clustering based technique proposed by [3] for the combine color space like RGB, YIQ, HSV. Images are segmented using K-means clustering technique and effective robust kernalized fuzzy C-means technique. In [10], the FCM clustering technique is used to segment the color image in L*u*v color space. The FCM clustering technique is represented for color image segmentation in CIEL*a*b color space in [11] by separating the color of an image using a decorrelation stretching technique. This decorrelation technique used to group regions and then FCM is applied for the segmentation of the satellite image. In [12], the robust color image segmentation method is proposed which is based on weighted FCM Clustering. The distance space between the pixel spaces and the eigenvector space is used to modify the objective function based on Euclidean distance for FCM. In this paper, the FCM clustering algorithm is applied to the different color spaces and the analysis of it is done. The analysis of this paper is useful for the selection of the color spaces for the color image segmentation.

OVERVIEW OF COLOR SPACES FOR COLOR IMAGE SEGMENTATION

The color space is a mathematical representation of the colors which allow the reproducible geometrical representation of the colors in 2D-3D space. Color spaces gives information about colors at each pixels of an image [13]. Color spaces give useful information like how color spectrum looks like as in [14]. Color space is the combination of color models and mapping function. Some common color spaces used for color image segmentation are RGB, YIQ, HSV, CIE XYZ among them some are device dependent like RGB (Red, Green, Blue), YIQ, YCbCR and some are device independent which include CIE XYZ, CIEL*a*b, CIEL*u*v. Different color spaces have their own application so, based on application color model can be used [13-14].

RGB Color Space

According to [13], in the RGB image each pixel of image is denoted by Red, Green and Blue components. It is widely used color space due to its simplicity. RGB color space represented by three dimensional, Cartesian coordinate system given in [15] other color spaces are produced by adding these three primary colors using linear and non-linear transformation. The combination of all three colors makes white color and the absence of all three colors makes black color. The coordinates inside the cube represent the values of Red, Green and Blue. The origin (0, 0, 0) shows black and (1, 1, 1) shows white [13, 15].

CIEL*a*b Color Space

According to [15] CIE (Commission International de l' Eclairage) color system was developed which meets the need of human observers. X, Y, Z are its main three parameters. The value of X, Y, Z computed using a linear transformation from RGB color coordinates. Equation (1) shows RGB to XYZ color transformation as in [15].

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} 0.607 & 0.174 & 0.200 \\ 0.299 & 0.587 & 0.114 \\ 0.000 & 0,066 & 1.116 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} \tag{1}$$

CIEL*a*b color space is derived from the CIE XYZ space. Where L stands for lightness of color, *a stands for red/green coordinates, *b stands for blue/yellow coordinates. It is device independent and able to control the intensity and color information more compare to RGB. It gives more difference between colors from each other as it device independent [16, 17]. The difference between two colors can be calculated as Euclidean distance which is in the Equation (2) as in [18].

$$\Delta E^* = [\Delta L^*2 + \Delta a^*2 + \Delta b^*2]1/2 \tag{2}$$

Where, ΔL is the difference between lightness or darkness, Δa is the difference in red and green and Δb difference in blue and yellow.

HSV Color Space

HSV (hue, saturation, value) is also widely used and more suitable color space to human eyes. The alternative color space of HSV is HSL (hue, saturation, lightness), HSI (hue, saturation, intensity). According to [13,15,17] hue (H) denotes base color or same shades either in degrees or numbers, saturation (S) describe how white the color is or the ratio of colorfulness of brightness. Saturation always represents in terms of degrees where 100% means color is fully saturated. Lightness defines darkness of color in terms of percentage where 0% mean black color and 100% mean white color. Table.1, color representation and its hue values as in [19] are given.

Table -1 Color Representation and its Hue Value

Hue(degree)	Hue(value)	Color
0 or 360	0 or 6	Red
60	1	Yellow
120	2	Green
180	3	Cyan
240	4	Blue
300	5	Magenta

Equation (3) to (6) shows the transformation from RGB space to HSV space [19].

$$H = across\frac{\frac{1}{2}(2R-G-B)}{\sqrt{(R-G)^2-(R-B)(G-B)}} \tag{3}$$

$$V= \frac{max(R,G,B)+min(R,G,B)}{2} \quad (4)$$

$$S=\left\{\frac{max(R,G,B)-min(R,G,B)}{max(R,G,B)+min(R,G,B)}\right\} for \; L < 0.5 \quad (5)$$

$$S=\left\{\frac{max(R,G,B)-min(R,G,B)}{2-max(R,G,B)+min(R,G,B)}\right\} for \; L \geq 0.5 \quad (6)$$

YIQ Color Space

According to [14, 15, 17] This color space is designed to separate chrominance (color information) from luminance (grayscale information Y) which obtained from the RGB model using linear transformation. It is device depended on which Y is a combination of red, green and blue intensities and useful for edge detection in image, the other two I (hue) and Q (saturation) represent color information, I contains orange and cyan hue information and Q contains green and magenta hue information. As it is Linear in nature and require less computational task also has minimum overlap between segmented and non-segmented regions. Equation (7) shows the conversion from RGB to YIQ as in [15].

$$\begin{pmatrix} Y \\ I \\ Q \end{pmatrix} = \begin{pmatrix} 0.299\ 0.587\ 0.114 \\ 0.596-0.274-0.322 \\ 0.211-0.253\ 0.312 \end{pmatrix} = \begin{pmatrix} R \\ G \\ B \end{pmatrix} \quad (7)$$

Where $0 \leq R \leq 1$, $0 \leq G \leq 1$, $0 \leq B \leq 1$

FCM FOR SEGMENTATION

FCM clustering is the modified version of the K-means (hard clustering) clustering. It is type of Soft clustering technique. Clustering is the process to classify the image in such a way that same group of data is in one group and at the same time different group of data having separation. In the FCM data elements can belong to two or more clusters based on the degree of belongingness.

FCM is based on the objective function and its aim to minimize this objective function as in [22].

$$J(U,Z) = \sum_{i=1}^{k} \sum_{j=1}^{N} \mu_{ij}^{p} \, ||y_j - z_i||^2 \quad (8)$$

Where, N is the number of data points, k is the number of clusters with $2 \leq k < N$,$x_k$is the pixel element of the image,μ_{ij}^{q} is the membership function which create fuzzy partitions for the randomly selected cluster center for each data poits that contains membership of y_j in the cluster i which having membership values between 0 and 1, z_i is the cluster center, p determines the degree of fuzziness of the resulting clusters or classification which is always p=2. In FCM partitioning is done by optimizing the objective function and membership function μ_{ij}^{q} iteratively to find best distance and location of the clusters and its values, cluster center z_i also updated with the $||.||^2$ which is any second order norm and Euclidean distance '$||y_j - z_i||^2$' between the image pixels (data elements) and the cluster center. $J(U,Z)$ is the weighted sum which is the distance between the cluster center and image pixels of the cluster. It is minimizing when image pixels are close to the cluster center, which pixel element close to the cluster center having high membership values and rest elements having low membership value which far from the cluster center. Steps for FCM are.

1. Load color image.
2. Initialize random number of cluster k, location of cluster center and termination criteria.
3. Calculate the fuzzy membership as in [22]

$$\mu_{ij}=\sum_{n=1}^{k}\left(\frac{||y_j-z_i||}{||y_j-z_n||}\right)^{\frac{-2}{p-1}} \quad (9)$$

4. Compute the fuzzy centers as in[22]

$$z_{(i)}= \frac{\sum_{k=1}^{N} \mu_{ij}^{p} y_j}{\sum_{k=1}^{N} \mu_{ij}^{p}} \quad (10)$$

5. Update the Fuzzy membership values $U^{(q+1)}$ where, U=(μ_{ij}).
6. Repeat step 4) and 5) until $||U^{(q+1)} - U^{(q)}|| \leq \beta$.

   Where, 'q' is the iteration step.

   β is the termination criterion between 0 and 1.

RESULTS OF FCM AND DISCUSSION

The flow of work for a segment the natural color images in different color spaces using the FCM clustering technique is given in Fig. 1. The FCM technique is tested on different color images, including satellite images which are collected from [23, 24]. Input images are color images which are sharpened for the sharpening the edges of the images mainly for satellite images. The sharper image converted into L*a*b, HSV, YIQ color spaces to check segmentation result and finally apply the FCM technique to segment the color image.

In Fig. 2(a), the input image is an RGB satellite image is shown. The sharpen RGB image is shown in Fig. 2(b). The FCM clustering algorithm is applied with termination criteria 0.00001and the number of cluster centers as 4, 5 and 6. Corresponding segmented result is shown in Fig. 2(c), (d) and (e) for cluster center as 4, 5 and 6, respectively. The input RGB image first sharpen and convert into L*a*b, HSV, YIQ color spaces. The original size of the image is 300*300 pixels and it was resizing into 185*185 pixels to reduce the computational time. In Fig. 3, Fig. 4 and Fig. 5, the different segmentation results using 4, 5 and 6cluster centers in L*a*b, HSV and YIQ color spaces are shown, respectively.

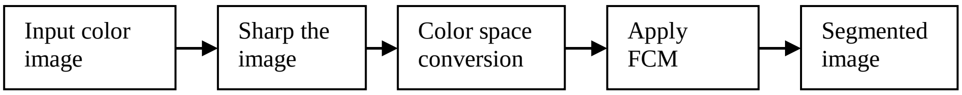
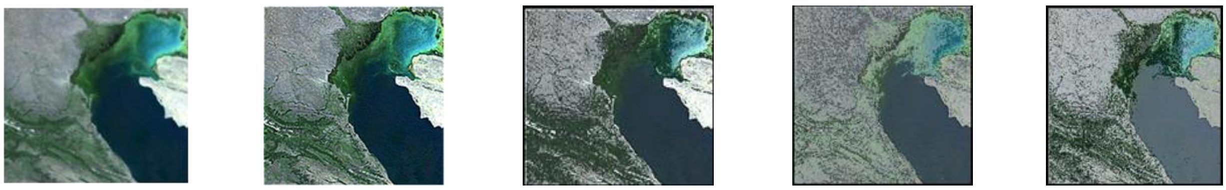
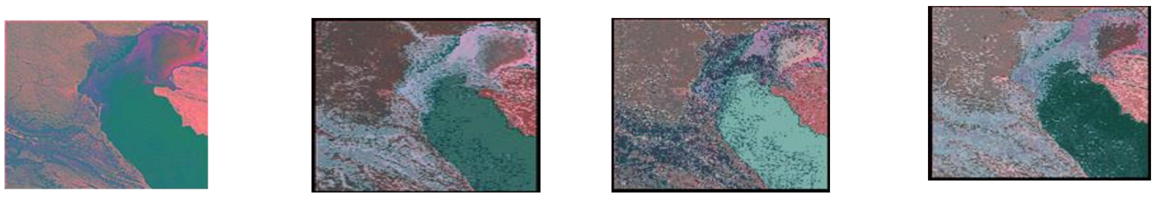


Fig. 1 Flow of Work



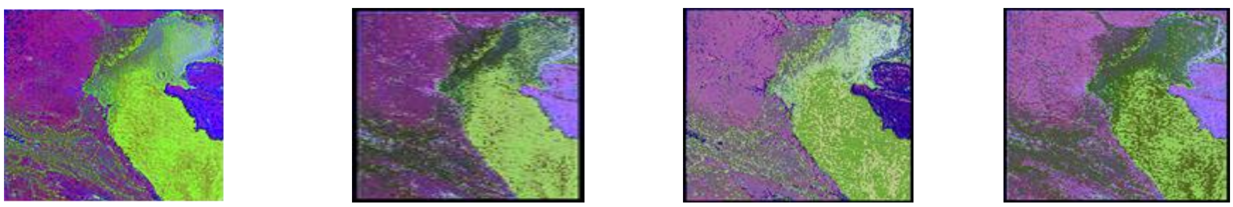
(a) (b) (c) (d) (e)

Fig. 2(a) Input RGB satellite image (b) sharpen RGB satellite image (c) segmented image using 4 clusters in RGB space (d) segmented image using 5 clusters (e) segmented image in RGB color space using 6 clusters



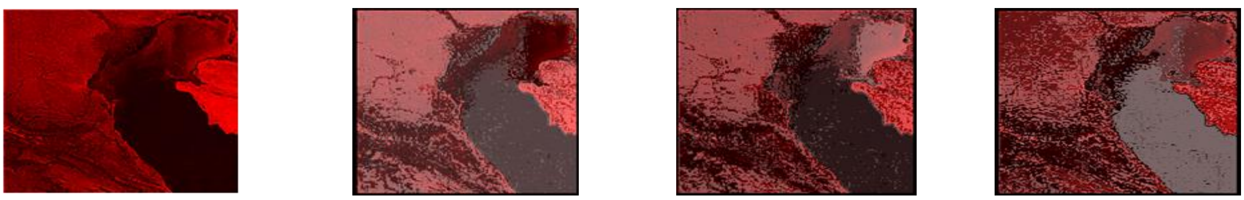
(a) (b) (c) (d)

Fig. 3(a) Input sharpen satellite image in L*a*b color space (b) segmented image in L*a*b color space (c) segmented image using 5 clusters (d) segmented image using 6 clusters in L*a*b color space



(a) (b) (c) (d)

Fig. 4(a) Sharpen input satellite image in HSV color space (b) segmented image in HSV color space (c) segmented image (d) segmented image using 6 clusters



(a) (b) (c) (d)

Fig. 5(a) Sharpen input satellite image in YIQ color space (b) segmented image using 4 clusters (c) segmented image using 5 clusters (d) segmented image using 6 clusters

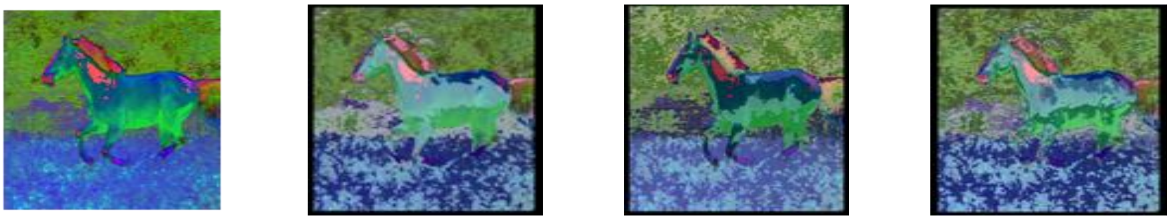
Fig. 6 shows that the input image is RGB image which is natural color image and shows the FCM segmented images and final segmented images with 5, 6, 7 clusters respectively. The original size of the image is 600*474 pixels and it was resizing into 235*297 pixels to reduce the computational time. Fig.7, Fig.8, Fig.9 shows the different segmentation results using 5, 6, 7 clusters in L*a*b, HSV, YIQ color spaces respectively.

(a) (b) (c) (d)

Fig. 6(a) RGB input image (b) segmented image in RGB color space using 5 cluster(c) segmented image in RGB color space using 6 clusters (d) segmented image in RGB color space using 7 clusters

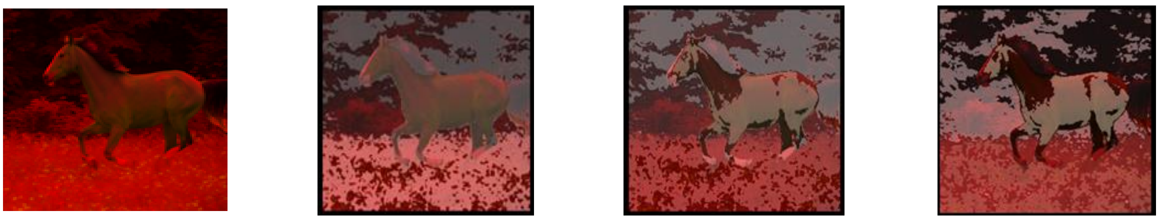
(a) (b) (c) (d)

Fig. 7(a) Input image in L*a*b color space (b) segmented image in L*a*b Color space using 5 clusters (c) segmented image in L*a*b color space using 6 clusters (d) segmented image in L*a*b color space using 7 clusters



(a) (b) (c) (d)

Fig.8 (a) Input image in HSV color space (b) segmented image in HSV color space using 5 clusters (c) segmented image using 6 clusters (d) segmented image in HSV color space using 7 clusters



(a) (b) (c) (d)

Fig.9 (a) Input image in YIQ color space (b) segmented image using 5 clusters (c) segmented image using 6 clusters in YIQ color space (d) segmented image using 7 clusters in YIQ color space

Table -2 Comparison of Segmentation Results of Satellite Image into RGB, L*a*b, HSV, YIQ Color Space using Different Clusters

Parameters	RGB			L*a*b			HSV			YIQ		
Figs	Fig. 2(c)	Fig. 2(d)	Fig. 2(e)	Fig. 3(b)	Fig. 3(c)	Fig. 3(d)	Fig. 4(b)	Fig. 4(c)	Fig. 4(d)	Fig. 5(b)	Fig. 5(c)	Fig. 5(d)
No. of clusters	4	5	6	4	5	6	4	5	6	4	5	6
No. of iteration	70	94	100	59	82	83	51	52	58	27	65	68
Execution time in seconds	2.72763	4.23252	5.01652	3.32019	4.31004	4.57221	2.70648	2.98759	3.59454	2.19067	2.90088	3.51072

Table -3 Comparison of Segmentation results of Natural Color Image in RGB, L*a*b, HSV, YIQ Color Space using Different Clusters

Parameters	RGB			L*a*b			HSV			YIQ		
Figs	Fig. 6(b)	Fig. 6(c)	Fig. 6(d)	Fig. 7(b)	Fig. 7(c)	Fig. 7(d)	Fig. 8(b)	Fig. 8(c)	Fig. 8(d)	Fig. 9(b)	Fig. 9(c)	Fig. 9(d)
No. of clusters	5	6	7	5	6	7	5	6	7	5	6	7
No. of iteration	100	100	100	66	71	100	72	60	100	44	56	81
Execution time in seconds	5.26827	5.78634	7.57719	4.14457	5.96771	8.24295	4.98522	5.17761	8.01557	3.68588	4.89271	6.97529

CONCLUSION

In this paper, color images are segmented using Fuzzy C-means (FCM) clustering technique in different color spaces and simulation results are compared. The FCM clustering technique is easy to understand and extract more information from images. It is good for color image segmentation because in the FCM data elements are belong to more than one cluster. Number of images are tested using the FCM in RGB, HSV, L*a*b, YIQ color spaces. Simulation results given in Table 2 and 3 show that conversion of color images reduces the computational cost compare to the RGB color space. It also shows that FCM requires an initial number of cluster centers and as the number of cluster center are selected higher, it gives better segmentation, but also increase the execution time, number of iterations and data complexity with extra segmentation of neighborhood cluster. But when the number of cluster centers is selected less than resulting clusters are overlapping.

REFERENCES

[1] Krishna Kant Singh and Akansha Singh, A Study of Image Segmentation Algorithms for Different Types of Images, *International Journal of Computer Science Issues*, **2010**, 7 (5), ISSN (Online): 1694-0784. ISSN (Print): 1694-0814.
[2] Ahmad Khan and Muhammad Arfan Jaffar, Genetic Algorithm and Self-Organizing Map based Hybrid Intelligent Method for Color Image Segmentation, *Applied Soft Computing*, **2015**, 32, 300-310.
[3] C Mythili and V Kavitha, Color Image Segmentation using ERKFCM, *International Journal of Computer Application*, **2012**, 41(20), 21-28.
[4] ERajaby, SM Ahadi and H Agheinia, Robust Color Image Segmentation using Fuzzy c-Means with Weighted Hue and Intensity, *Digital Signal Processing*, **2016**, 51, 170-183.
[5] RYogamanglam and BKarthikeyan, Segmentation Technique Comparison in Image Processing, *International Journal of Engineering and Technology*,**2013**, 5(1), 307-313.
[6] Nida MZaitoun and Musbah J Aqel, Survey on Image Segmentation Techniques, *International Conference on Communication, Management and Information Technology, Procedia Computer Science*, **2015**, 65, 797-806.
[7] Natasha, A Review Paper on Image Segmentation Techniques, *International Journal of Computer Science and Communication Engineering*, **2016**, 5 (1), 32-36.
[8] Preeti, A Survey on Image Segmentation using Clustering Techniques, *International Journal for Research in Applied Science and Engineering Technology*, **2014**, 2 (5), 51-55.
[9] Soumi Gosh and Sanjay Kumar Dubey, Comparative Analysis of K-means and Fuzzy C-means Algorithms, *International Journal of Advanced Computer Science and Application*, **2013**, 4 (4), 35-37.
[10] Juraj Horvath,Image Segmentation using Fuzzy c-Means, *Symposium on Applied Machine Intelligence*, Herl any, Slovakia, **2006**.
[11] Tara Saikumar, PYungader, PShreenivas Murthy and B Smitha, Color based Image Segmentation Using Fuzzy C-means Clustering, *International Conference on Computer and Software Modeling*, Singapore, **2011**.
[12] Yujie Li, Huimin Lu, Yingying Wang, Lifeng Zhang, Shiyuan Yang and Seiichi Serikawa, Robust Color Image Segmentation Method Based on Weighting Fuzzy C-Means Clustering, *IEEE/SICE International Symposium on System Integration*, Singapore, **2012**.
[13] VKalist, P Ganesan,BSSatish, MMJenitha and KBShaikh, Possiblistic-Fuzzy C-means Clustering Approach for the Segmentation of Satellite Images in HSL Color Space, *Procedia Computer Science*, **2015**, 57, 49-56.
[14] P Ganeshan and VRaijani, YIQ Color Space based Satellite Image Segmentation using Modified FCM Clustering and Histogram Equalization, *International Conference on Advance in Electrical Engineering*, **2014**, 1-5, doi: 10.1109/ICAEE. 2014.6838441.
[15] HD Cheng, XHJiang, Y Sun and Jingli Wang, Color Image Segmentation: Advance and Prospects, *Pattern Recognition*, 2001, 34, 2259-2281.
[16] Seema Bansal and Deepak Aggarwal, Color Image Segmentation using CIE Lab Color Space using Ant Colony Optimization, *International Journal of Computer Application*, **2011**, 29(9).

[17] Akshay P Vartak and Vijay Mankar, Colour Image Segmentation - A Survey, *International Journal of Emerging Technology and Advanced Engineering*, **2013**, 3 (2), 681-688.
[18] *http://sensing.konicaminolta.us/2014/04/identifying-color-differences-using-l-a-b-or-l-c-h-coordinates/*
[19] *http://www.equqsys.de*
[20] Priyansh Sharma and Jenkin Suji, A Review on Image Segmentation with its Clustering Techniques, *International Journal of Signal Processing, Image Processing and Pattern Recognition*, **2016**, 9(5), 209-218.
[21] P Tamjiselvy, V Palanisamy and TPurusotham, Performance Analysis of Clustering Algorithm in Brain Tumor Detection of MR Images, *European Journal of Scientific Research*,**2011**, 3, 321-330.
[22] SM Mahajan and YKDubey, Color Image Segmentation using Kernalized Fuzzy C-means Clustering, *Proceeding of IEEE International Conference on Communication System and Network Technologies*, **2015,** 1142-1146.
[23] *http://www.landcover.org*
[24] *http://Berkeley image segmentation dataset*