



## Smoke Image Segmentation Based on Color Model

Deng Xing<sup>1,2</sup>, Yu Zhongming<sup>2,3</sup>, Wang Lin<sup>2</sup>, Li Jinlan<sup>1,2</sup>

<sup>1</sup>School of Science, Guizhou Minzu University, Guiyang, P.R.China, 550025;

<sup>2</sup>Guizhou provincial key laboratory of pattern recognition and intelligent system, Guiyang, P.R.China, 550025;

<sup>3</sup>Liupanshui Normal University, Liupanshui, P.R.China, 553000

**E-mail:** 794682477@qq.com, yzm69333@163.com, wanglin@gznc.edu.cn, 470202030@qq.com

**Abstract:** Smoke is the most significant feature in the process of fire, so it's possible to rely on smoke detection to detect fire. While the smoke image segmentation is the most difficult and also indispensable step in the analysis of smoke image detection. In order to improve its accuracy and effectively exclude the disturbances of non-smoke image, and lower the false alarm rate, it puts forward a kind of smoke image segmentation based on color model. It uses K-means clustering in Lab color space and threshold segmentation in HSV color space, then merges the two results. Finally, it uses the method of shen filter and regional mark to denoise, Experimental results on segmentation of smoke image show that the proposed method is able to segment smoke from the background.

**Keywords:** Image segmentation; K-means algorithm; Color space; LAB; HSV

**Paper received: 01/02/2015**

**Paper accepted for Publication: 05/07/2015**

## INTRODUCTION

Image segmentation is the process of dividing and extracting ROI region. Its main methods include histogram threshold<sup>[1]</sup>, edge detection<sup>[2]</sup>, region segmentation<sup>[3]</sup>, clustering method<sup>[4]</sup>, fuzzy method<sup>[5]</sup>, etc. The histogram threshold method is intuitive and less calculation without known information when image segmentation. However it has the possibility of region incompleteness when this method is used separately. Edge detection has better effect for images of low noise and less complication than ones with complicated edges and unevenness of brightness distribution which cause problems in image segmentation for its disconnected boundary. The results of region growing segmentation are dependent on the choice of seeds. Fake region and false boundary can easily appear when segment image by using split-and-merge method, while noise has less effect on it. Clustering method is a kind of statistical classification algorithm which easily realize in color space, but it needs to pre-determine the cluster number. Fuzzy method is an effective way in the field of image processing, however its real-time processing is not good. Given the own characteristic of objects and ambient influence in image segmentation, effective image segmentation is always a difficulty and hard to reach a pleased segmentation results.

In the point of smoke image itself, it has the features of abundant color information, less obvious textures and subject to ambience. Therefore, this paper proposes a smoke image segmentation method based on color model and K-means algorithm which choose color model of HSV and LAB, In HSV space using k-means clustering, in the LAB using threshold segmentation, the method combines two of segmentations together as a whole and filters the noise.

## SELECTION OF COLOR MODEL

### 1. Lab color space

Lab color space, also called Lab space, is a kind of color model enacted in 1931 and improved and named in 1976 by the international commission on illumination (CIE) . Lab color model consists of three channels, L means lightness, value [0,100]; a, the positive number refers to red(+127a), the negative number refers to green(-128a); b, the positive number refers to yellow(+127b), the negative number refers to blue (-128b). Although Lab color space has the feature of evenness of color distribution, it cannot contain all of the colors within human beings' vision. Take CIEXYZ, which was built in 1931, as an example, it's a special color space detected directly based on human being's color vision. Thus RGB space is needed to turn into XYZ space before the space conversion of LAB into RGB<sup>[6, 7]</sup>.

RGB → XYZ :

$$\begin{cases} X = 0.43 \times R + 0.38 \times G + 0.19 \times B \\ Y = 0.21 \times R + 0.72 \times G + 0.07 \times B \\ Z = 0.018 \times R + 0.11 \times G + 0.87 \times B \end{cases} \quad (1)$$

XYZ → LAB :

$$\begin{aligned} \text{if } X > 0.008856 \quad \text{then } f(X) = X^{\frac{1}{3}}, \text{else } f(X) = 7.787 X + 0.138 \\ \text{if } Y > 0.008856 \quad \text{then } f(Y) = Y^{\frac{1}{3}}, \text{else } f(Y) = 7.787 Y + 0.138 \\ \text{if } Z > 0.008856 \quad \text{then } f(Z) = Z^{\frac{1}{3}}, \text{else } f(Z) = 7.787 Z + 0.138 \end{aligned}$$

$$\begin{cases} L = 1.16 f(Y) - 0.16 \\ a = 2.27 (f(X) - f(Y)) + 0.5 \\ b = 0.91 (f(Y) - f(Z)) + 0.5 \end{cases} \quad (2)$$

## 2. HSV color space

On account of the weaknesses of the less visual perceptibility of human eye and the low similarity of space color in RGB color space, this paper choose this HSV color models which is a more people-oriented information model. The HSV color space is represented as an upside-down hexagonal pyramid, shown in Figure 1. The top surface is a regular hexagon and its six angles respectively stand for the location of six color: red, yellow, green, green grass, blue and pinkish red. H, the Hue, means the location of spectral color, the values come from the results of passing V pixels. S, the Saturation, satisfies the range of [0,1], where S=0 represents the value of color in the center of hexagon, where S=1 represents the value of color in the frame of hexagon. V means brightness with the range of [0,1], where V=0 represents black in the bottom; where V=1 represents white in the top. Because the images collected in experiment are RGB models, for the following image segmentation, it needs to convert RGB models into HSV models<sup>[8-11]</sup>.

$$\begin{aligned} & RGB \rightarrow HSV \\ & Max = \max(R, G, B), Min = \min(R, G, B) \\ & H = \begin{cases} \frac{G - B}{Max - Min} \times 60^\circ, \text{if } (R = Max) \\ (2 + \frac{B - R}{Max - Min}) \times 60^\circ, \text{if } (G = Max) \\ (4 + \frac{R - G}{Max - Min}) \times 60^\circ, \text{if } (B = Max) \end{cases} \text{if } Max = Min \quad H \text{ is Pure grey} \quad (3) \\ & S = \frac{Max - Min}{Max} \\ & V = Max \end{aligned}$$

## K-MEANS CLUSTERING ALGORITHM

K-means clustering algorithm is one of the classical clustering algorithm which depends on partitioning algorithm in the feature space. It uses iteration method to extract spatial clustering of each pixel in the feature space with continuously adjusting clustering center and divides the pixel of data base into K categories with making sure the distance minimum from each pixel to the included center to realize the segmentation of picture<sup>[12, 13]</sup>.

The detailed steps of K-means clustering algorithm are as following:

Step1: According to the minimum erroneous judgments rule, selecting K data points as the initial clustering center  $\lambda_1, \lambda_2, \dots, \lambda_k$ .

Step2: Calculating the distance from each data point to he clustering center in accordance with the principle of minimum.

Step3: Calculating the average values of vicissitudinous clustering and adjust the clustering centers again.

Step4: Compute the sum  $G(x_i)$  of distances between pixels and its cluster center, then judge if cluster center  $\lambda_i$  and  $G(x_i)$  changed. If it is, repeat Step2, otherwise terminate iterative and end this algorithm.

## IMAGE SEGMENTATION BASED ON COLOR MODEL AND K-MEANS CLUSTERING

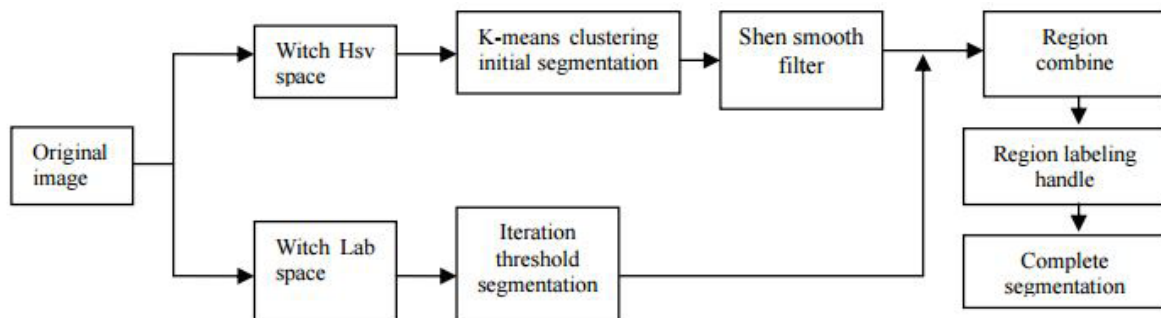


Figure 1 Algorithm Flow Diagram

### 1. K-means clustering image segmentation based on HSV modal

Firstly, switching the image from RGB space to HSV space and making use of K-means clustering method to realize initial segmentation for the image. Secondly, according to the information of the image, assigning the pixels which color is closing to the same category. The experiments show that clustering 3 is the best. Then using the Shen smoothing filter<sup>[14]</sup> to eliminate the shadows and the isolated points, witch can make the clustering image much better. At last, eliminating the isolated points and interferential pixels of peripheral image in the region labeling method.

Shen filter is a low-pass filter, we can use it to get first-order derivative and second-order derivative. Assuming the initial signal is  $I(x)$  ( $x=0,1,2,\dots,N$ ), then filtering the signal to get  $I_L(x)$  from left to right.

$$\begin{cases} I_L(x) = I(x) & x = 0 \\ I_L(x) = aI(x) + (1-a)I_L(x-1) & x = 1, 2, \dots, N \end{cases} \quad (4)$$

Filtering the signal again from right to left to get  $I_R(x)$

$$\begin{cases} I_R(x) = I_L(x) & x = N \\ I_R(x) = aI_L(x) + (1-a)I_R(x+1) & x = N-1, N-2, \dots, 1, 0 \end{cases} \quad (5)$$

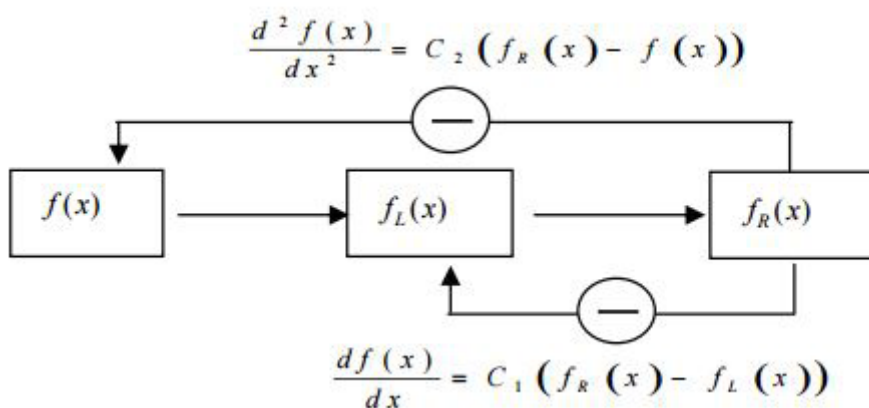


Figure 2 Shen Operator Algorithm Flow Diagram

## 2. Image segmentation based on the threshold of LAB modal

First we need to switch the image from RGB space to CIEXYZ space, then switching the image from CIEXYZ space to LAB space again. In the LAB space, there are three components needed to process regionally. Threshold segmentation of each region is decided by improved iteration method. Finally the image is binarized. Due to the considering that this paper's studying is smoke image whose signal is wide spreading in the respect of brightness and information. Besides the Lab's color gamut is wider than RGB. Using arithmetical operation to the L and B components can eliminate the interferent of the image according to the experiment.

## 3. Regional combination

HSV color modal is closer to people's perception and separation for the color, so HSV color modal well suited smoke image's analysis and processing. Considering the characteristic of uniform distribution of Lab's color modal, we can combine the HSV modal with LAB modal to get a better result. Do the mathematic for the binary images getting from K-means clustering based on HSV color space and improved iterative threshold segmentation based on L\*a\*b\* color space.

## 4. Regional labeling processing

Regional labeling processing is the post processing after K-means clustering segmentation and threshold segmentation for the smoke image. Labeling all the default modules, then eliminating the noise which area is smaller than the threshold T, as the following:

$$J(i, j) = \begin{cases} 0, & \text{where the } S(J(i, j)) \text{ less than the threshold } T \\ 1, & \text{where the } S(J(i, j)) \text{ greater than or equal to the threshold } T \end{cases} \quad (6)$$

### ANALYSIS OF EXPERIMENTAL RESULTS

In this article, the method of using color model and K-means clustering to segment smoke image was implemented. The K-means clustering was used in HSV space where smoke, weeds and human being were classified into three types with the principle of minimum misjudgment to initialize cluster center. Then, compute the distance between each pixel and its cluster center with the principle of minimum loss to classify their categories. After that, re-compute the cluster centers by averaging all of the pixels in the cluster. Finally, compute the sum of distances between pixels and its cluster center, then judge if the cluster center changed. The process can repeat over and over again until convergence is attained.

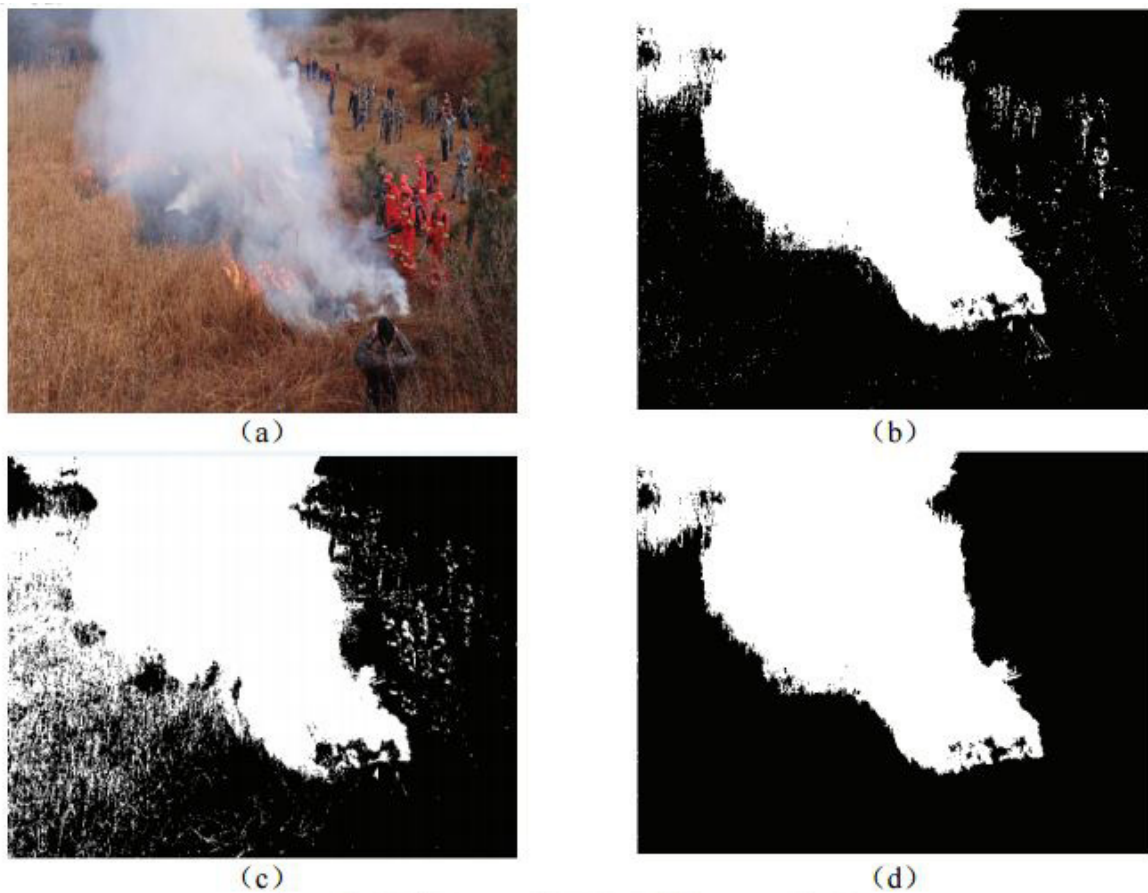


Figure 3 This Proposed Method of Segmentation Image

Fig (a) is Original image , Fig (b) is the K-means clustering based segmentation image converted into HSV color space. Fig (c) shows the segmentation result of L component using the iterative threshold to segment smoke image in converted LAB space. The segmentation result proposed in this study is showed in Fig (d). From Fig (b), it can be seen that there's still some noise following the Shen process of filtering and noise deduction. From Fig (c), it can be seen



that there's still a lot of noise in the final result. While, as shown on Fig (d), it can be seen that the method proposed in this article of smoke image segmentation based on color model and K-means clustering can segment from background, and meanwhile the noise is fairly low. The result shows that this method is better than individually using K-means clustering in HSV color space and using iterative threshold in Lab color space, In order to verify the feasibility of this method, there're a number of experiments had been tested. Some of the experimental results are shown as below:

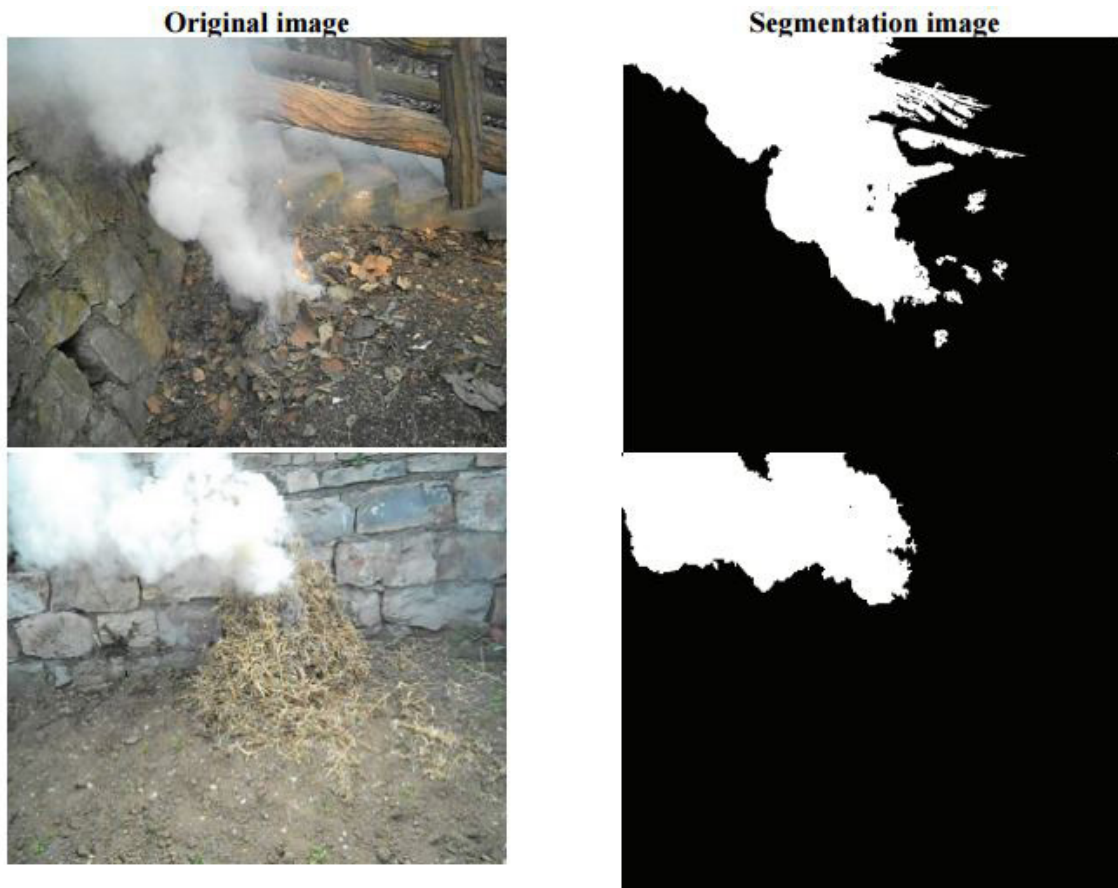


Figure 4 Some Experimental Segmentation Image

## CONCLUSION

In this paper we introduce a method of image segmentation based on color model (HSV/LAB), using improved iterative threshold to segment in LAB color space and K-means clustering in HSV color space, then doing region merge for the twice segmentation results, at last getting the final segmentation image through the way of region label to eliminate noise. The segmentation experimental result against smoke image shows that this proposed method, which overcomes the limitation of single algorithm, is more effective than individually using K-means clustering in HSV color space and using iterative threshold in Lab color space. While the problems of over-segmentation and under-segmentation is required to be resolved in our further research.

## BIBLIOGRAPHIC REFERENCES

- [1] Rafael C. Gonzalez, Richard E. Woods, et al. Digital Image Processing, Second Edition[M]. Beijing: Publishing House of Electronics Industry, 2003
- [2] Khaled M. Shaaban, Nagwa M. Omar. Region-based Deformable Net for automatic color image segmentation[J]. Image and Vision Computing, 2009, 27(10):1504-1514
- [3] Takanashi, Tetsuya, Shin, Jungpil. Color Image Segmentation Based on Region Growing Algorithm[J].EN,2012,7(16):152-160
- [4] Aristidis L, Nikos V, Jakob J.V. The global k-means clustering Algorithm[J]. Pattern Recognition, 2003,36:451-461
- [5] Cheng H.D, Li J. Fuzzy homogeneity and scale-space approach to color image segmentation[J]. Pattern Recognition, 2003, 36(7): 1545-1562
- [6] Pang Xiaomin, Min Zijian, Kan Jiangming. Color image segmentation based on HSI and LAB color space[J]. Journal of Guangxi University: Nat Sci Ed, 2011, 36(06): 976-980 (In Chinese)
- [7] Huang Rui, Sang Nong, Luo Dapeng, QilingTang. Image segmentation via coherent clustering in Lab color space[J]. Pattern Recognition Letters, 2011, 32(7): 891-902
- [8] Tony, F. Chan, Sung Hakang. Total Variation Denoising and Enhancement of Color Images Based on the CB and HSV Color Models[J]. Journal of Visual Communication and Image Representation, 2001, 12(4): 422-435
- [9] Osvaldo, S. Adilson Gonzaga. A new approach for color image segmentation based on color mixture[J]. Machine Vision and Applications, 2013, 24(3): 607-618
- [10] Guo Yinghua. Image segmentation based on HSV color space[J]. Heilongjiang Metallurgy, 2011, 31(02): 35-37 (In Chinese)



- [11] Zhang Zheng, Xue Guixiang, Gu Zecang. Digital image processing and machine vision[M]. Press of Beijing Posts & telecom press,2010 (In Chinese)
- [12] Zalik K R. An efficient K-means clustering algorithm[J].Pattern Recognition Letters, 2008,29(9):1385-1391
- [13] Kanungo T,Mount D M. A Local Search Approximation algorithm for k-means clustering[J]. Computational Geometry,2004,28(2/3):89-112
- [14] Shen J, Castan S. An Optimal Linear Operator for Step Edge Detection[J]. CVGIP: Graphical Model and Image Processing,1992,54(2) :112-133