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Fire Detection using YCbCr Color Model

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ABSTRACT

The proposed method adopts rule based color model which are defined based on luminance and chrominance content present in an image. YCbCr color space effectively isolates luminance from chrominance compared to other color spaces like RGB and normalized RGB (rgb). The proposed method not only separates fire flame pixels but also isolates high temperature fire centre pixels by taking into account statistical parameters of fire image in YCbCr color space like mean and standard deviation. In this method four rules are defined to separate the true fire region. Two rules are defined for segmenting the fire region and other two rules are defined for segmenting the high temperature fire centre region. The results are obtained and tested for a 200 images and achieves 88% of higher true fire detection rate and less false detection rate. The proposed method can be used for real time forest fire detection with moving camera.

Keywords : Fire detection, YCbCr color model, Image processing, mean, standard deviation

I. INTRODUCTION

A fire alarm is very useful for security reasons. To reduce loss of life and property from fire, an early warning is an imperative. Presently almost all the fire detection system uses sensors. The accuracy, reliability and positional distributions of the sensor determine the betterment of the system. For high precision fire detection systems, large numbers of sensors are needed in the case of outdoor applications. Sensors also need a frequent battery charge which is impossible in a large open space. Sensors detect fire if and only if it is close to fire. This will lead to damaging of sensor. Computer vision based systems replaces conventional fire detection systems, due to the rapid development of digital camera technology and video processing. Computer vision based systems use three stages.

1. Flame pixel classification
2. Segmentation of moving object
3. Analysis of the candidate region

The performance of the fire detection system depends on the performance of the fire pixel classifier which generates major areas on which rest of the system operates. Thus a precise fire pixel classifier is needed with high true detection rate and less false detection rate. However some rules are defined for fire pixel classification.

The fire pixel classification can be considered both in gray scale and color video sequences. Many rules have been proposed for detection of fire in an image. Each method gives robust results for specified set of images. However, results may be varying due to image size, orientation, contrast and color. In nondocument images, detecting fire is more challenging because of variation in fire size, color and position. The simple flow chart for fire detection in an image is shown in the figure 1.

T.Chen et al. [1], developed a set of rules to separate the fire pixels using R, G and B information. B.U. Totryin et al. [3] used a mixture of Gaussians in RGB color space. B.U. Totryin et al.[2] employed a Hidden Markov Models to detect the motion characteristics of the fire flame that is fire flickering along with the fire pixel classification.

II. METHODS AND MATERIAL

A. Approach

In RGB color space it is not possible to separate a pixel's value in to intensity and chrominance. The chrominance can be used in modeling color of the fire rather than modeling its intensity. This gives a very strong representation for fire pixels. So there is a need for transforming RGB color space into one of the color space where the separation between intensity and chrominance is more discriminate. Based on the above concept we choose YCbCr color space for the classification of fire pixels. Also conversion from RGB to YCbCr color space is linear.

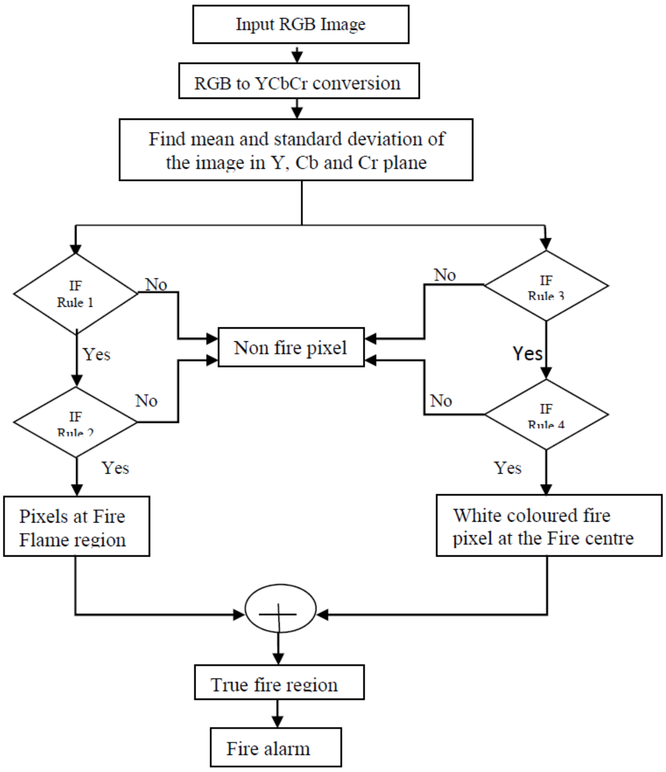

Figure 1. Flowchart of proposed fire detection system

This section deals with the proposed fire pixel classification method. It uses YCbCr color space. Because YCbCr color space separates luminance information from chrominance information. The conversion from RGB to YCbCr color space is

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.2568 & 0.5041 & 0.0979 \\ -0.1482 & -0.2910 & 0.4392 \\ 0.4392 & -0.3678 & -0.0714 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 128 \\ 128 \\ 128 \end{bmatrix}$$

'Y' is Luminance component, 'Cb' is the Chrominance blue component and 'Cr' is the chrominance red component. The range of 'Y' is [16 235]. The range of 'Cb' and 'Cr' are [16 240].input image is shown in fig.2 and output of conversion from RGB to YCbCr color space is shown in fig.4

$$Y_{mean} = \frac{1}{MXN} \sum_{x=1}^{M} \sum_{y=1}^{N} Y(x,y)$$

$$Cb_{mean} = \frac{1}{MXN} \sum_{x=1}^{M} \sum_{y=1}^{N} Cb(x,y)$$

$$Cr_{mean} = \frac{1}{MXN} \sum_{x=1}^{M} \sum_{y=1}^{N} Cr(x,y)$$

$$Cr_{std} = \sqrt{\frac{1}{M\ X\ N} \sum_{x=1}^{M} \sum_{y=1}^{N} (C_r(x,y) - C_{r_{mean}})^2}$$

M×N : Total number of pixels in the input image.

Using mean of the image, one can find the standard deviation of the image in Y, Cb and Cr plane. New method uses standard deviation of Cr plane.

Rules are made to detect the fire. It use YCbCr color space in order to separates chrominance information from luminance information. Totally 4 rules are made Rule I and Rule II are used for the segmentation of fire flame region. Rule III and Rule IV are used for the segmentation of centre fire pixels (high temperature region).

Finally the image obtained by satisfying Rule I & II and the image obtained by satisfying Rule III & IV are added to get the true fire image.

Four Rules are listed below

Rule 1

$AI\ (x, y) = \{$

$I(x, y), if\ Y(x, y) > Cb(x, y)$

$0, Otherwise$

I(x,y) represents the input RGB image.

Y(x,y) and Cb(x,y) are luminance and chrominance Blue values at different special locations (x,y).

AI(x,y) is the pixel which satisfies Rule I.

Rule 2

$AII\ (x, y) = \{$

$AI\ (x, y), if\ Y(x, y) > Ymean\ , Cr\ (x, y) > Crmean$

$0, Otherwise$

Rule 3

$AIII\ (x, y) = \{$

$I(x, y), if\ Cb(x, y) \geq Y(x, y) > Cr\ (x, y)$
$0, Otherwise$

Rule 4

$AIV\ (x, y) = \{$
$AIII\ (x, y), if\ Cr < \tau\ Crstd$
$0, Otherwise$
'τ' is a constant

Rule 1: Defines about RGB color space i.e, R > G > B can be translated in to YCbCr color space as Cb >Y.

Rule 2 : Since flame region is the brightest region in scene and Cr component in the fire region is more, the mean values of Y and Cr channels in the overall image (Ymean and Crmean) contains valuable information. In fire region, the value of Y and Cr component at each spacial location is greater than mean value of the Y component (Ymean) and Cr component (Crmean) respectively. However, for the pixels in the non fire region one of these two conditions are not satisfied. These observations are verified over a number of experiments with images.

Rule 3: At high temperature, centre of the fire region is of white in color. This gives the information that the chrominance red component is very less and chrominance blue component is more at the fire centre. To explain this idea many high temperature fire images are collected from the internet and their centers are analyzed. From the result, it is observed that at the fire centre Y component is greater than the Cr component and Cb component is greater than Y component. Based on this observation of large number of test images Rule III can be formulated.

Rule 4: While segmenting the fire centre based on luminance, some of the white colored regions like cloud and smoke are segmented from the input image. To overcome this problem, the texture of the fire region is also incorporated. Fire and the non fires like clouds have different textures. Texture of the fire region can be defined by the statistical parameters of the image like mean, median, standard deviation etc. In the proposed method standard deviation of the image for the Cr plane is incorporated i.e., Crstd. This observation is verified for countless experiments with images containing high temperature fire. 'τ' is a constant. The value of 'τ' is determined by the analysis of image set consisting of 1000 images Based on the analysis conducted on the image set τ value is selected as 7.4[4].

III. RESULTS AND DISCUSSION

Figure 2. Original Image

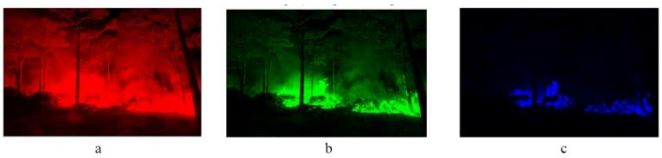

Figure 3(a, b,c) RGB images

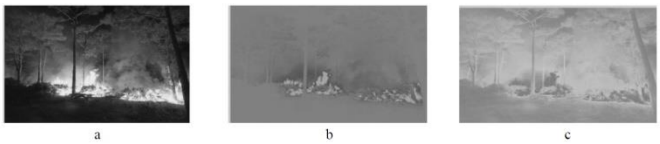

Figure 4.a) Y component b)Cb Component c)Cr Component

Figure 5. Segmented fire region by a) using Rule I. b) Using Rule II. c) satisfying Rule I and II
d) Using Rule III e)Using rule IV f) satisfying Rule III and IV

Figure 6. Fire Detected Region

Analysis is carried out using more than hundred of images. This fire set consists of flame like objects such as sun, red colored car, red rose etc. The proposed method effectively segments fire flame and the high temperature fire centre (white colored region) with high detection rate and low false detection rates.

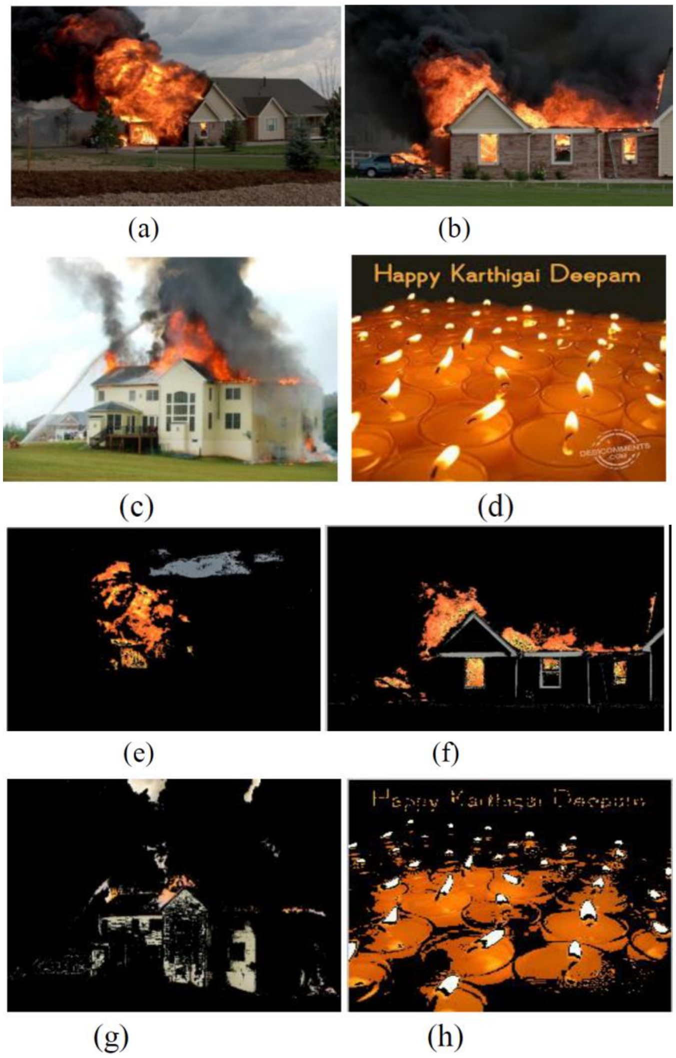

Figure 7. (a,b,c,d) Input RGB images and (e,f,g,h)fire detected images

IV. CONCLUSION

There are numerous strategies accessible to perform the fire identification and area detection in regular scene pictures. Here the results are obtained by designing four rules. In this paper, image processing based fire pixel classification using YCbCr color space is proposed. The proposed method not only separates fire flame pixels but also separates high temperature fire centre pixels by taking in to account of statistical parameters of fire image. It uses four rules to classify the fire pixels. Computational complexity of the proposed system is very less, hence it can be used for real time forest fire detection. The proposed system achieves 99.4% fire detection rate and 12% false alarm rate.

V. REFERENCES

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