Al-Mustansiriyah Journal of Science
ISSN: 1814-635X (print), ISSN:2521-3520 (online)
Volume 29, Issue 4, 2018
DOI: http://doi.org/10.23851/mjs.v29i4.414

Research Article **Open Access**

Study Fire Detection Based On Color Spaces

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ArticleInfo

Received
06/12/2017

Accepted
06/03/2018

Published
05/05/2019

Abstract
In this paper, the fire color feature is analysis and test on a set of color spaces (RGB, HSV, YCbCr, Lab, Yiq) to account the hue component and determination the best color space to represent the properties of fire and used in fire detection to increase accuracy and reduce the detection time and false alarms, four common types of fire (wood, cork, cloth, paper or cardboard) were used to compare them with an image containing all the basic colors and analyze them and calculating Scale factor that depending on the histogram for hues value.

Keywords: Color space, Fire detection, Scale factor, Fire feature color.

الخلاصة
في هذا البحث تم تحليل واختبار خصائص لون النار واختبارها على الفضاءات اللونية (RGB, HSV, YCbCr, Lab, Yiq) لحساب مكون الـ (hue) وتحديد أفضل فضاء لوني لتمثيل خصائص النار واستخدامها في الكشف عن الحرائق لزيادة الدقة وتقليل وقت الكشف والإنذارات الكاذبة. وقد تم استخدام أربعة أنواع شائعة من النار (الخشب والفلين والقماش والورق اوالكرتون) لمقارنتها مع صورة تحتوي على جميع الألوان الأساسية وتحليلها من خلال حساب عامل المقياس بالاعتمادا على الرسم البياني ل قيمة اللون (hue) للأشكال.

Introduction

Fire detection is critical to protecting the environment and safety of people. Fire and smoke detection in the video are particularly applicable to industrial surveillance and surveillance used to observer buildings and the environment as a side of an early warning technique to start fire Outbreak.

systems video can detect uncontrolled fires at an early step before they become catastrophic.

To the fire, detection may use the color feature and the movement features usually to check the real burning fire, these dynamic

features include fire sudden movements of flame, shapes for change, growth rate, and oscillation.

The flame has troubled phenomena. In case of disturbance stream, the nature of the chaos of fire is an important feature. If the features of an object show a fast variable time behavior then this is an important sign of a flame in the scene. Marbach *et al.*[1] YUV was used as a chromatic space for video fire detection where they proposed a method based on the use of the time derivative of the Y lighting component to represent the firing region pixels. The chrominance U and V were used to distinguish the color value of the candidate pixels to determine whether the region was an area Fire or not. In addition to the lighting and chromatic, they used the change in motion in their way. The results were reduced by the rate of false alarms to one alarm in week Çelik *et al.*[2]. They developed two models for detecting smoke and fire using the image processing techniques. In addition to specifying the number of bases to shoot pixels, and then render to the concept to the fuzzy logic system. A rule table is created based on the probability value the pixel is considered to be fire. The result was 99% as a precision ratio, however, and this cannot be used for real-time detection. The threshold may be used to detect smoke but may fail because the smoke color depends on the type of material being burned. Vipin *et*

al.[3] proposed an approach to detecting forest fires based on image processing and using a color model where he adopted an algorithm using RGB and YCbCr color space.
He tested two groups of images one of which contained a fire; the other contains a fire-similar region with the highest detection rate and low False alarms. But the algorithm is weak in the calculation it can be used in real-time to detect fires. Seebamrungsat *et al.*[4] they proposed a fire detection system that can use in buildings to detect early for ignition fire by using HSV and YCbCr color space .and with given conditions to separate fire color's (red, orange, yellow) and high brightness from the background. Fire
detection is checked by using frame differences method. Thou-Ho *et al.*[5], they proposed a method to analyzed statistics RGB color information of the fire images, where adopted the method of a color threshold to segment the images and extracted the fire suspected region.

Color Spaces

Hue represented one of the main properties of a color, where used to refer to just the pure spectrum colors and we will account hue for every color space to detect the best space can use to detect fire color feature.

RGB color space

In the RGB color space, the colors are represented as a cube unit.
Where the cube is expressed using three axes, red, green and blue, and any point inside the cube represents a unique color.
Where r, g, b describe the red, green and blue components that are used to represent one pixel on the screen[6].
The eight corners of the cube can be represented in black, red, green, blue, yellow, purple, blue and white.
The gray scale is located inside the cube. It starts from black to the opposite corner of the cube where the color is white.
In this area, we will illustrate the graph value of the shot images and their variation from the rest of the color spaces depending on the value (Hue) and as in Figure 1.

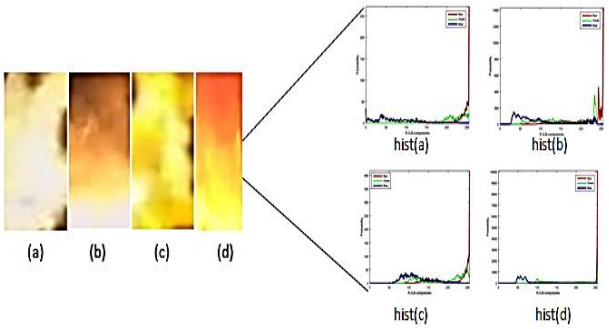

Figure 1: Represent RGB color space histogram to foure type fire.

HSV color space

The HSV color space (hue, saturation, value)
The model describes colors similar to how the human eye to Sensitive color. Where the human color vision reflected better than the RGB, YUV and
YIQ models, which are targeted primarily for devices applications.
represent RGB Color in relations of a mixture of basic colors, where, HSV describes the color using more Comparisons are familiar with color, saturation, and brightness[8][9].The conversion from RGB color space to HSV color space is given by[6]:

$$V = max\{R, G, B\} \quad (1)$$

$$S = \frac{max - min}{max} \quad (2)$$

$$H = \begin{cases} \dfrac{G - B}{6(max - min)} \\ \dfrac{1}{6}(2 + \dfrac{B - R}{max - min}) \\ \dfrac{1}{6}(4 + \dfrac{R - G}{max - min}) \end{cases} \quad (3)$$

where $max = \max(R, G, B)$ and $min = \min(R, G, B)$. All three components,H, S, and V are in the range [0, 1].

YCbCr color space

The YCbCr color space Considered as part of the component video standard and belongs to the family of television transmission color spaces. Y represents the luminosity component, while is Cb and Cr
represent the chrominance of the blue (color deviation from gray on a blue-yellow axis) and red (color deviation from gray on a red-cyan

axis) primaries respectively[7]. The conversion from RGB color space to YCbCr color space is given by[8]:

$$\begin{aligned} Y &= 0.299 * R + 0.587 * G' + 0.114 * B' \\ Cb &= -0.169 * R' - 0.331 * G' + 0.500 * B' \\ Cr &= 0.500 * R' - 0.419 * G' - 0.081 * B' \end{aligned} \quad (4)$$

And to calculate hue value by the equation.

$$H_{cbcr} = tan^{-1}\frac{cr}{cb} \quad (5)$$

Y IQ Color Space

This color space is used in televisions in the United States. where The National Television System Committee (NTSC) defines a color space as YIQ. One of the main advantages of this format is that grayscale information is separated from color data[8][9]. Therefore, having three components—luminance (Y), hue (I), and saturation (Q)—enables the same signal to be used for both color and black-and-white sets. the Luminance signal (Y) is determined by adding the basic color signal in percentages (30%) for the red color, (59%) for the green color, (11%) for the blue color[8] and Luminance represents grayscale information,whereas the last two components make up *chrominance* (color information) by[10].

$$Y = 0.299r + 0.587g + 0.144b \quad (6)$$

Components (i) and (q) are given by relationship:

$$I = 0.596r - 0.270g + 0.322b \quad (7)$$

$$Q = 0.211r - 0.253g + 0.312b \quad (8)$$

The value of (h) is given by the relationship:

$$h_{iq} = \tan^{-1}\frac{i}{q} \quad (9)$$

L*a*b* Color Space

The L*a*b* space is the basic color spaces where it space consists of a luminosity layer 'L*', and layer 'a*' indicating where the color is located along the red and green axis, the layer 'b*' indicating where the color is located along The blue and yellow axis, In L*a*b*, defines the L axis with lightness and extends from 0 (black) to 100 (white). samples for which A=B=0 are the achromatic component. Therefore, the L-axis represents the luminosity component scale of grays from black to white[11]. The three coordinates L, A and B are computed from the depending on the values X, Y, and Z as follows[6]:

$$L = \begin{cases} 116\left(\frac{Y}{Y_n}\right)^{\frac{1}{3}} - 16 & if \ \frac{Y}{Y_n} > 0.008856 \\ 116\left(\frac{Y}{Y_n}\right)^{\frac{1}{3}} & if \ \frac{Y}{Y_n} \leq 0.008856 \end{cases} \quad (10)$$

$$A = 500\left(f\left(\frac{X}{X_n}\right) - f\left(\frac{Y}{Y_n}\right)\right) \quad (11)$$

$$B = 200\left(f\left(\frac{Y}{Y_n}\right) - f\left(\frac{Z}{Z_n}\right)\right) \quad (12)$$

where X_n, Y_n, and Z_n describe a specified white object color stimulus and the function f is defined as[6]:

$$f(x) = \begin{cases} X^{\frac{1}{3}} & if \ X > 0.008856 \\ 7.787X + \frac{16}{116} & if \ X \leq 0.008856 \end{cases} \quad (13)$$

The B coordinate describes the yellowness–blueness. The coordinates A and B have a range of approximately [−100, 100] [11], and chroma, hue angle given by[12]:

$$C_{AB} = \sqrt{A^2 + B^2} \quad (14)$$

$$H_{AB} = tan^{-1}\frac{B}{A} \quad (15)$$

Suggested methods in Analysis fire feature

The color is important feature can be used to detect fire, where it can be affected by many effects such as external lighting and the environment and to increase the effectiveness of fire detection must establish strong standards

for fire color analysis analysis where the image is analyzed into several spaces such as (HSV, YCbCr, Yiq, Lab).
inThis paper we will focus on the properties of (H) in fire analysis and detection where a flame feature in general fire, the color of the flame is usually between red and orange and yellow.
The proposed method is include on comparing the huse of all color spaces and the color of fire by calculating probability between the two ratios.

$$p(H) = \sum_{j=1}^{k} nj/k \quad (16)$$

Where nj is the frequency j=1, 2, 3… K, K being the number of frequency in hue component.
where the histogram will be calculated for four types of fire and compared with an image containing all the basic colors. If x coordinate represents the H value and Y coordinate represents the histogram of H component, the difference between the highest value and the lowest value of the histogram values and each color space will be calculated according to the equations by:

$$dxchart = abs(ymx - ymn) \quad (17)$$

$$dxfire = abs(ymx - ymn) \quad (18)$$

The value of scale is calculated by:

$$Scale = \left(\frac{dxfire}{dxchart}\right) \quad (19)$$

This three equations to determine the best color space to detect fire.
This method will be applied to each color space. As shown in Figure 2, where if we analyze the color properties of the fire and determine the best chromatic space based on hue (h) values. This process is very important in detecting fire more accurately and also helps to reduce the rate of false alarms. In this method was used four sections of the most common types of fire Such as (paper or carton, cork, cloth and wood). And convert all image to HSV color space and Calculate the color value of (h) and compare it with the color value of (h) for the official colors image containing 16.777.216 colors by using the histogram as shown in Table 2 and determine its largest and smallest (h)value by account scale factor value.

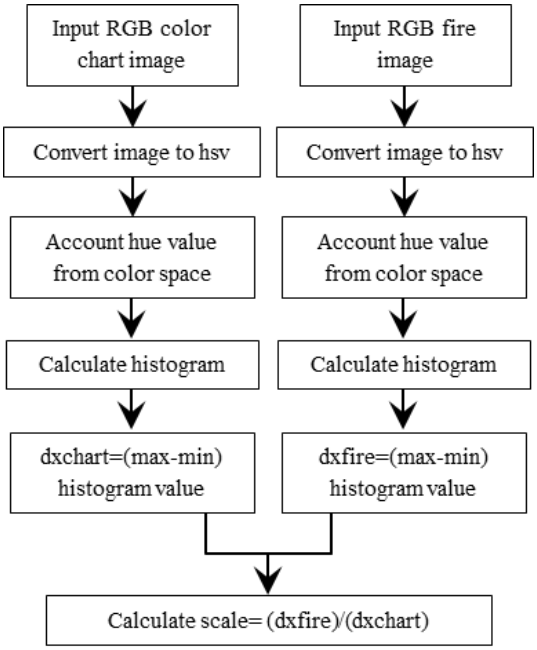

Figure2: Flow chart to propose method.

Result and discussion

In this paper, the color properties of fire analyzed and tested on chromatic components in spaces (HSV, YCbCr, Lab, Yiq) and determination of the best color space to determine the properties of fire and its use in fire detection to increase accuracy and reduce detection time and false alarms.
The four common types of fire that containing all the basic colors and analyze them by calculating histogram based on the hue (h) value as Table 1.
In HSV color space the amount of the color value (h) of the color image and fire and the next step will be calculated the amount of the scale value according to the Table 1. These method are applied to each chromatic space and the space containing the lowest value for the scale consider The best chromatic space as based on histogram value as shown in Figure 3.
When using the YCbCr color space, the value of (h) and scale for the images to calculate as shown in Table 1, were calculated based on the histogram and as illustrated in Figure 4.
When using the Lab color to account the value of (h) and calculate the value of scale as in

Table1, and histogram value was extracted as in Figure 5.

And when using the YIQ color space the value of (h) and calculate the value of scale in Table1 Was extracted based on the histogram value was extracted as in Figure 6.

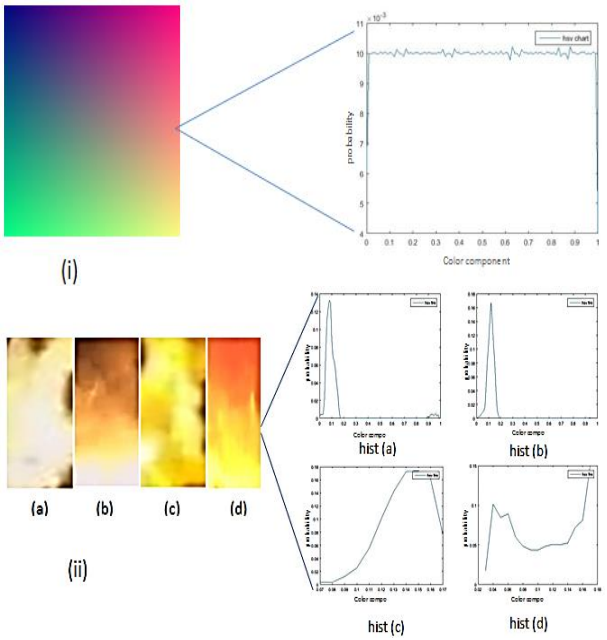

Figure 3: Represent HSV color space to (i) histogram to hue image colore basic, (ii) histogram to foure type fire part colore.

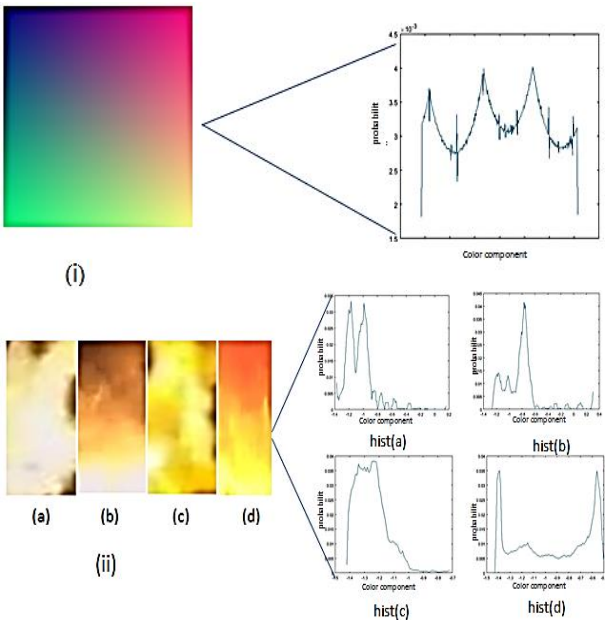

Figure 4: Represent YCbCr color space to (i) histogram to hue image colore basic, (ii) histogram to foure type fire part colore.

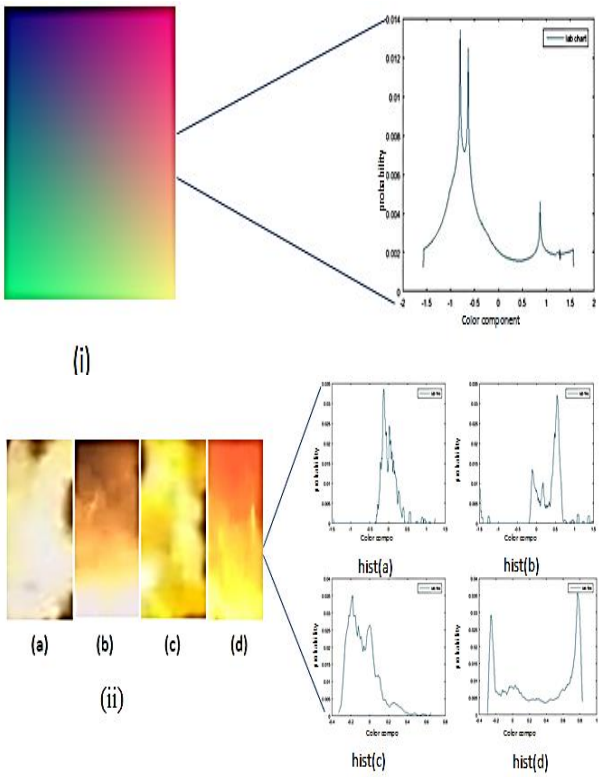

Figure 5: Represent Lab color space to (i) histogram to hue image colore basic, (ii) histogram to foure type fire part colore.

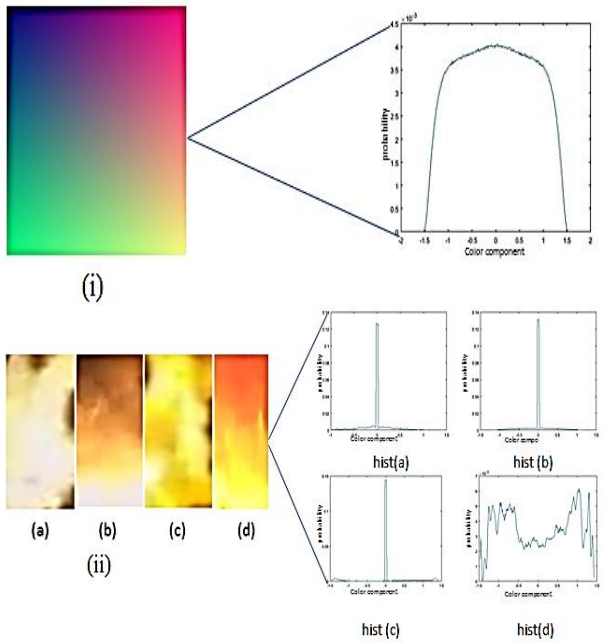

Figure 6: Represent YIQ color space to (i) histogram to hue image colore basic, (ii) histogram to foure type fire part colore.

This below table represents the minimum and maximum values of a histogram to e value of

(hue) for each chromatic space, and the scale factor is calculated, which represents the amount of change in the min and max values. The space with the lowest value in the scale factor is the best.

The table also contains the value of length, which represents the number of steps of Hue value where it was determined the HSV is the best chromatic space because it contains the lowest value of the scale factor as shown in Table 1.

Then comes the color space YCbCr in the next and then Yiq and was the worst value in the test of chromatic space is (Lab).

Table 1: Represent Maximum and Minimum Hue Value for Every Color Space to Foure Type of Fire and Image Color Base and Scale Value and Length.

	Hsv	Ycbcr	Lab	Yiq													
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	
Fire part value	max	0.1700	0.1700	0.9900	0.9400	-0.7200	-0.5000	0.3000	0.1600	0.6500	0.8300	1.5000	1.2300	1.4200	1.4300	1.2000	1.1100
	min	0.0700	0.0300	0	0	-1.4200	-1.4300	-1.2700	-1.3700	-0.3300	-0.3000	-1.4700	-1.4600	-1.4600	-1.4600	-1.2400	-0.9700
Scale (fire/chart)	0.1000	0.1400	0.9900	0.9400	0.2229	0.2962	0.5000	0.4873	0.3121	0.3599	0.9459	0.8567	0.9381	0.9414	0.7948	0.6775	
length	11	15	100	95	71	94	158	154	99	114	298	270	289	290	245	209	

Table 2: Represent Maximum and Minimum Hue Value for Every Color Space Image Color Base .

		Hsv	Ycbcr	Lab	Yiq
Chart value	min	1	1.5700	1.5700	1.5300
	max	0	-1.5700	-1.5700	-1.5400

Conclusion

In this paper, we analyze the color spaces of the fire images to determined the best color space that used as a function of feature , this study depending on hues component in chromatic space (RGB, HSV, YCbCr, Lab, Yiq) color spaces depending on scale factor, we can conclude the best color space is HSV used in fire detection and from its histogram, the H value between (0-0.2).

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