A Methodology for Fire Detection Using Colour Pixel Classification

Nurul Shakira Bakri[#], Ramli Adnan[#], Abd Manan Samad[*], Fazlina Ahmat Ruslan[#1]
[#]Faculty of Electrical Engineering
[*]Centre of Surveying Science and Geomatics, Faculty of Arc., Planning and Surveying
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[1]fazlina419@salam.uitm.edu.my

***Abstract*—Lately, fire outbreaks are common issues and its occurrence could cause severe damage toward nature and human properties. Thus, fire detection has been an important issue to protect human life and property and has increases in recent years. This paper focusing on the algorithm of fire detection using image processing techniques i.e. colour pixel classification. This Fire detection system does not require any special type of sensors and it has the ability to monitor large area and depending on the quality of camera used. The objective of this research is to design a methodology for fire detection using image as input. The propose algorithm is using colour pixel classification. This system used image enhancement technique, RGB and YCbCr colour models with given conditions to separate fire pixel from background and isolates luminance from chrominance contrasted from original image to detect fire. The propose system achieved 90% fire detection rate on average.**

Keywords-fire detection, image processing, RGB, YCbCr colour models

I. INTRODUCTION

Fire, particularly fire in structures, can spread rapidly and cause incredible death toll and property. Subsequently, early fire location and cautioning is basic. Fire indicators, smoke locators and temperature finders have been broadly use to ensure property and give cautioning of flames. In any case, smoke and temperature location detected by sensor, is slower than light and colour discovery, which is the substantive recognition strategy propose in this paper [1]. Besides, to cover the whole region possibly subject to flame, a fire identification system is propose in light of shading location. The objectives of the propose study are to study a methodology to detect fire using image processing technique and implement the methodology using fire pixel classification from the RGB input image.

The sensors are likewise not relevant for open-air environment and in huge foundation settings, for example, mountains and high building. Because of the quick improvement of computerized camera innovation and propelled content based image processing, there is a noteworthy pattern to supplant customary fire identification system with PC vision based framework as additionally [2, 3]. In this paper, a calculation is propose for flame recognition which consolidates nonspecific shading model in light of RGB colour space, to make a general fire identification system. To begin with the guidelines created in the RGB and rgb colour spaces (R>G>B) are transform to YCbCr colour space [4]. The strategy introduce a technique that utilizes YCbCr colour model with conditions to separate brilliance of the fire from the foundation and encompassing light. This calculation which was based on identification and the following was utilized with the targets to lessen false alert rate of flame which oftentimes happen with the customary electronic strategies [5].

Literature in system identification can be acquire to relate hypothesis between the presence systems. Design acknowledgment is a logical strategy whose point is the arrangement of items into the classifications relying upon the application. The items incorporate numbers, images or flag waveform. Simin Rasouli et al. [6] proposed three parameters; fuel, oxygen and temperature and use temperature more than 40 degrees Celsius as reference. They evaluate the data using neural network and support vector machines. Moreover, it is possible to do image classification using neural network. Turgay Celik and Hasan Demirel presented a metric based on double form distinction pictures to quantify the smouldering level of flame flares into more classes, for example, no-fire, little, medium and huge flames [7]. The proposed colour model also achieves 80.0% flame detection when the parameter used also colour and colour space model technique. The significances of this methodology are to reduce the damage caused by fire incidents that affect nature and human interest and improve the performance of fire detection.

This paper is organize in the following manner: Section II provides the methodology, Section III explains results and discussions, and finally, Section IV is on conclusions.

II. METHODOLOGY

The proposed technique receives run based colour model because of its less multifaceted nature and viability. YCbCr shading space adequately isolates luminance from chrominance contrasted with other colour spaces like RGB colour space. The proposed technique isolates fire pixels as well as isolates high fire focus pixels by assessing accurate parameters of flame images in YCbCr colour space.

978-1-5386-0389-5/18/$31.00 ©2018 IEEE

In this strategy four condition are shape to isolate the genuine fire locale. Two condition are utilize for sectioning the fire locale and other two condition are utilize for dividing the high fire pixel focus area. To reduce false location and improve genuine fire recognition rate, the results obtain are compare to the techniques used in the literature. Flow chart in Figure 1 portray arrange by stage the execution of the proposed method.

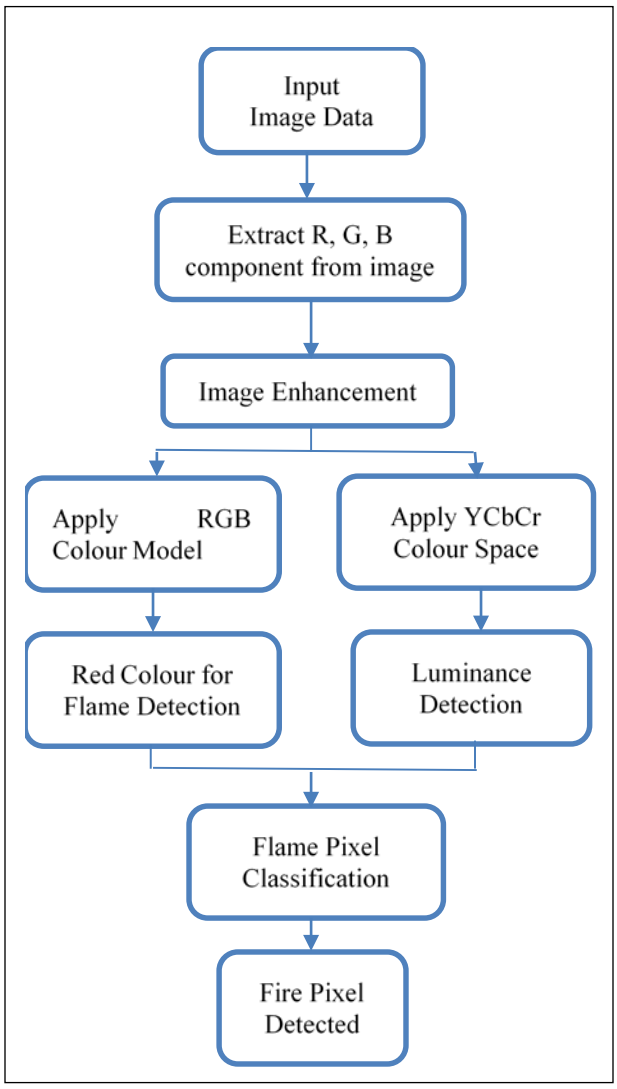

Figure 1. Flow Chart

Stage 1: Image Enhancement

Image enhancement technique have been broadly utilize as a part of numerous utilizations of image processing where the subjective nature of image is essential for human interpretation. Contrast is a critical consider any subjective assessment of image quality.

Contrast is make by the distinction in luminance reflected from two adjoining surfaces. As it were, contrast is the distinction in visual properties that makes a protest discernible from different object and the background. In visual observation, contrast is control by the distinction in the colour and brightness of the object with other objects. Our visual system is more delicate to contrast than total luminance.

Stage 2: RGB Colour Model

A fire image described by utilizing its colour properties. There are three different components of colour pixel: Red, Green and Blue, RGB. The colour pixel can be extract into these three individual parts R, G and B, which is utilize for colour recognition. RGB colour model is utilize to distinguish red data in image. The intensity of R more than G and G more than B to discriminate the relationship between the three colour channel which increase the degree RGB colour model qualities. In fire, colour recognition R ought to be more separated around then the other part, and in this way R changes into the control shading direct in a RGB image for flame.

The condition for R as to be over some red threshold value, RTH will improves the system. These conditions for fire pixel in image chosen as taking after;

Condition 1: R > RTH Condition 2: R>G>B

Then the result then converts to YCbCr colour space where Y represent single component, Cb and Cr represent the difference between the blue component and red component to a reference value respectively.

Stage 3: YCbCr Colour Model

YCbCr colour space is pick purposely on the account of its capacity to separate enlightenment data from chrominance more adequately than the other colour spaces. The tenets characterized for RGB colour space with a specific end goal to distinguish conceivable fire-pixel applicants can be change into YCbCr colour space and analysis can be perform. The luminance data which is identify with the force is actually anticipated that would be overwhelming for a fire pixel. Theoretically, from the flame images the more noteworthy the contrast amongst Y(x,y) and Cb(x,y) segments of a pixel, the higher the probability that it is a fire pixel. So we can abridge general connection between Y(x,y), Cb(x,y), and Cr(x,y) as takes after:

Formulated as, $Y(x,y) \geq Cb(x,y) \geq Cr(x,y)$

Figure 2 shows the RGB to YCbCr colour space conversion formula.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.2568 & 0.5401 & 0.0979 \\ -0.1482 & -0.2910 & 0.4392 \\ 0.4392 & -0.3678 & -0.0714 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix}$$

Figure 2. Formula conversion of RGB to YCbCr

III. RESULT AND DISCUSSION

The validation as theoretically assess the algorithm in the pixel extracted from image data. This validation procedure utilizes a truth demonstrate, with which the outcomes was thought about. The affectability and accuracy analyses of the algorithm validation will be discussing related to the efficiency of the algorithm stated in following;

A. Contrast Enhancement

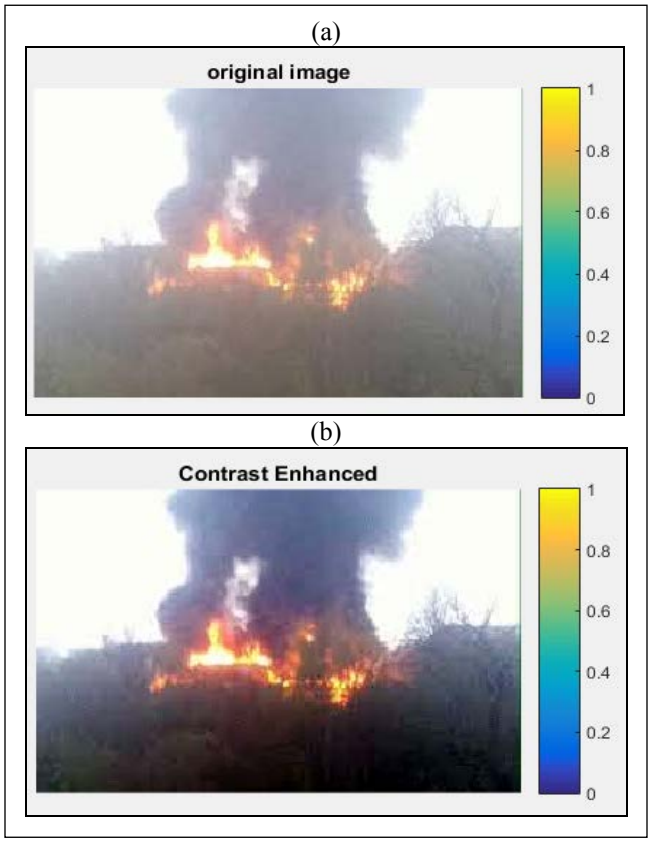

Figure 3. (a) Original RGB image, (b) RGB Image after contrast Enhancement

Contrast Enhancement technique builds the contrast of the image by mapping the estimations of the information intensity image to new values with the end goal that, as a matter of course, 1% of the data is immerse at low and high intensities of the input data. In this study, as shown in Figure 3(a), for the sample image, imadjust technique is use for contrast enhancement. Concentrating on sample image, it would be preferable for the fire to stay out at about the same brightness while enhancing the contrast in other areas of the image.

The point of image enhancement is to enhance the data in pictures for human viewers, or to provide more information as well as give better contribution for other computerized image preparing techniques processing strategies.

Figure 3(b) shows the RGB sample image after contrast enhancement. To date, contrast enhancement is assume to be vital part in improving image's quality. A few past reviews demonstrated that contrast enhancement technique skilled to clean up the undesirable commotions and improve the image's brightness and contrast. The finding about image contrast enhancement, it gave clearer and cleaner image to better and less demanding fire pixel screening detection.

B. RGB Colour Model

The purposed of RGB colour model algorithm are based on the reference value of R, G, B in colour flame. Colour flame have R, G, B value of (226,88,34). Extracted red component more than the other component resulted proofs of the improving performance of fire pixel classification rate of the proposed system.

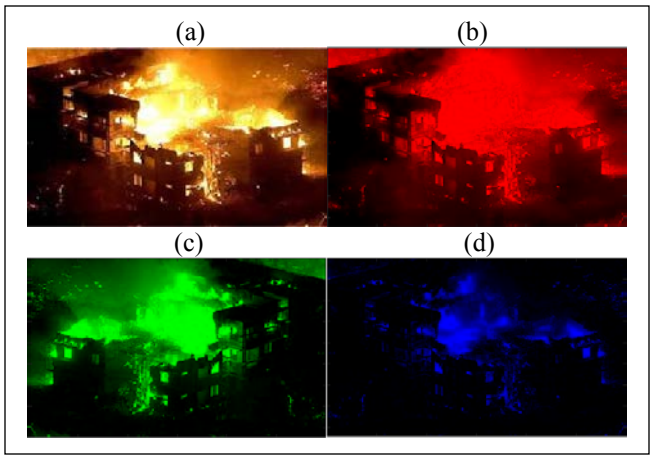

Figure 4. (a) RGB sample image of fire, (b) Red component (c) Green component (d) Blue component

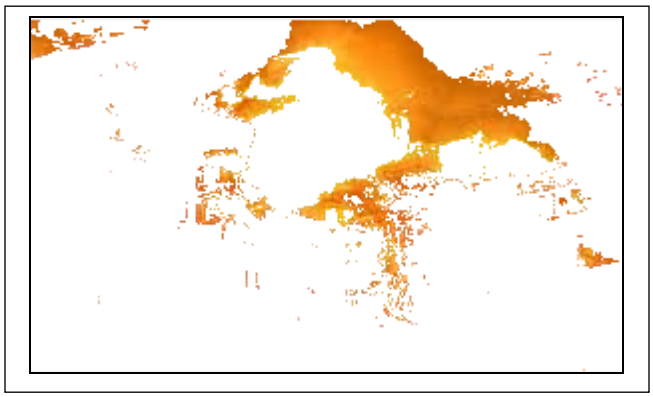

Figure 5. Image after RGB colour model applied

One RGB sample image has been taken as in Figure 4(a). There are sub images of different colour component in algorithm extracted from sample image frames having fire. Figure 4(b) having red extraction component, Figure 4(c) having blue extraction component, and Figure 4(d) having green extraction component, and with the algorithm applied, above two conditions; R>RTH and R>G>B the red component was extracted more than other component resulted as shown in Figure 5.

C. YCbCr Colour Model

The capability to recognize luminance data from chrominance data more sufficiently, YCbCr colour space is utilize as a part of our model as opposed to other colour spaces based on the result.

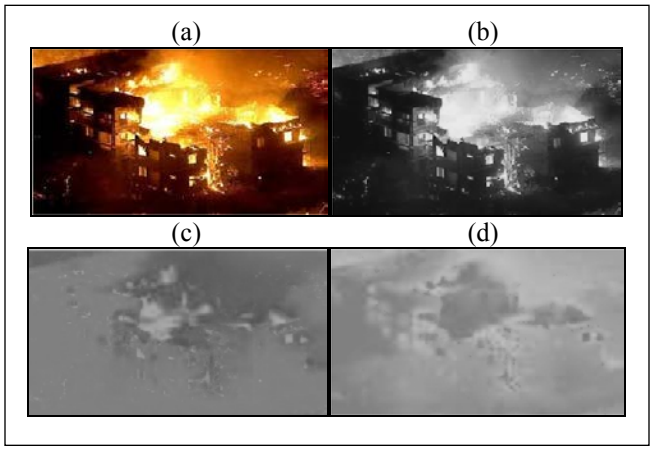

Figure 6. (a) Original image, (b) Y component, (c) Chrominance Blue, (d) Chrominance Red

With a specific end goal to make Y, Cb, Cr parts from acquired RGB image, colour space transformation was utilized to change each RGB pixel to shape a relating Y, Cb, Cr image from Y channel, Cb channel and Cr channel comparison. Figure 6(b) shows Y component extraction, 6(c) for chrominance blue and Figure 6(d) shows chrominance red extraction from original image in Figure 6(a) under equation;

$$F(x,y) = \begin{cases} 1, & if\ Y(x,y) > Ymean, Cb(x,y) < Cbmean, Cr(x,y) > Crmean \\ 0, & otherwise \end{cases}$$

For a fire pixel identification system, $Y(x,y) > Cb(x,y) > Cr(x,y)$ conditions in YCbCr colour space were satisfied, while not for non-fire pixels, where (x,y) is spatial location of a fire pixel. Such system can be useful for detecting fires where sensors are not suitable at the location such as forest.

D. Fire Pixel Classification

In this stage, detection of flame in RGB and YCbCr colour space is compile together for the outcome to be precise and overcome the false alarm. Therefore, the image ought to satisfy all the four conditions to be considered as flame. In this stage, the yield expected to demonstrate the fire district in two-fold image as though the fire distinguished. Else, just full dark shaded picture will be display.

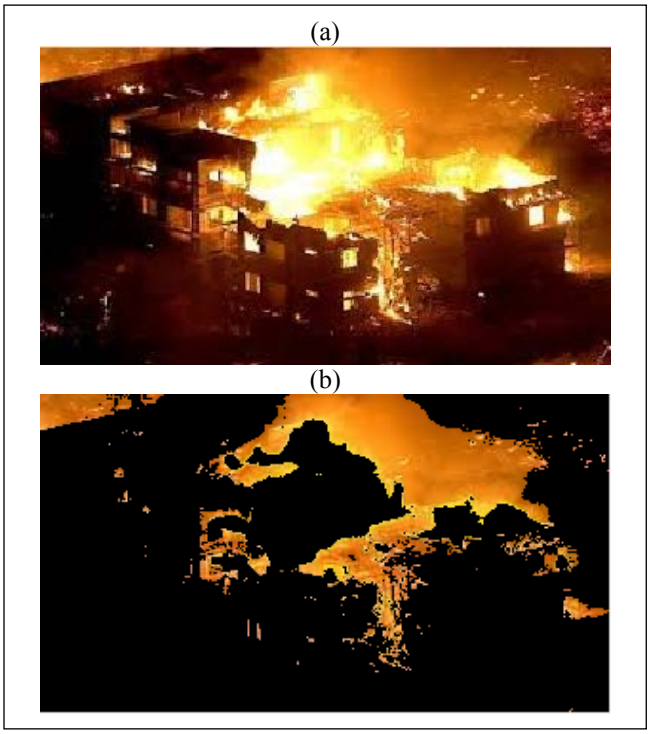

Figure 7. (a) Contrast Enhanced Image, (b) Fire Pixel Detection

The image of fire after pixel classification as mentioned above is show in Figure 7. Figure 7(a) show that the image after image contrast enhancement and Figure 7(b) show that the fire detection in the image after all colour model are applied and all condition are fulfil.

Based on 10 images, final validation is carry out to evaluate the algorithm. The results are compare where the model is utilize in the process. The validation of algorithm tabulated in Table I that described the possibility for the affectability and accuracy of the analyses based on 10 different fire scenario images.

TABLE I. DIFFERENT FIRE SCENARIO IMAGES

Data set	Detected by Human	Detected by Algorithm (DA)	Missed by Algorithm (MA)
1	Present	Positive	Negative
2	Present	Positive	Negative
3	Present	Positive	Negative
4	Present	Negative	Positive
5	Present	Positive	Negative
6	Present	Positive	Negative

Data set	Detected by Human	Detected by Algorithm (DA)	Missed by Algorithm (MA)
7	Present	Positive	Negative
8	Present	Positive	Negative
9	Present	Positive	Negative
10	Present	Positive	Negative

Fire pixel detected by algorithm (DA) compared with overall data set to carry out the final accuracy evaluation. The accuracy of the algorithm calculated by using the Equation (1);

$$\text{Accuracy} = GA/(10)*100 \quad (1)$$

Hence based on our analysis over the 10 images;

$$\text{Accuracy} = 9/(10)*100$$
$$= 90\%$$

IV. CONCLUSION

As a conclusion, the system had effectively perceived fire presence in the image that is perform in view of 10 images. Analysis show that the algorithm has higher fire location rate in 90% accuracy. The system is ready to separate the things in encompassing (non-fire) or reflected things that have same incentive as flame pixel recognition; false fire alert could be maintain a strategic distance from.

Thus, this system could build up exceedingly solid reliable system. Therefore, for future work, the algorithm can be use in fire detection in real video sequences as the algorithm performs well in fire detection in RGB image input data.

ACKNOWLEDGMENT

This research work is supported by Lestari Fund 600-IRMI/MYRA5/3/LESTARI(0007/2016). The acknowledgement also goes to Faculty of Electrical Engineering and Research Management Center (RMC) of Universiti Teknologi MARA, Shah Alam, Selangor.

REFERENCES

[1] Q. Yu, D. Zheng, Y. Fu, and A. Dong, "Intelligent Fire Alarm System Based on Fuzzy Neural Network," in *2009 International Workshop on Intelligent Systems and Applications*, 2009, pp. 1-4.

[2] T. Celik, H. Ozkaramanlt, and H. Demirel, "Fire Pixel Classification using Fuzzy Logic and Statistical Color Model," in *2007 IEEE International Conference on Acoustics, Speech and Signal Processing - ICASSP '07*, 2007, pp. I-1205-I-1208.

[3] T. Çelik, H. Özkaramanlı, and H. Demirel, "Fire and smoke detection without sensors: Image processing based approach," in *2007 15th European Signal Processing Conference*, 2007, pp. 1794-1798.

[4] S.-C. L. Kumarguru Poobalan, "Fire Detection Algorithm Using Image Processing Techniques," 2015.

[5] S. Y. Foo, "A rule-based machine vision system for fire detection in aircraft dry bays and engine compartments," *Knowledge-Based Systems,* vol. 9, pp. 531-540, 1996.

[6] S. Rasouli, O. C. Granmo, and J. Radianti, "A methodology for fire data analysis based on pattern recognition towards the disaster management," in *2015 2nd International Conference on Information and Communication Technologies for Disaster Management (ICT-DM)*, 2015, pp. 130-137.

[7] T. Çelik and H. Demirel, "Fire detection in video sequences using a generic color model," *Fire Safety Journal,* vol. 44, pp. 147-158, 2009.