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FIRE RECOGNITION USING RGB AND YCBCR COLOR SPACE

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ABSTRACT

Fire departments in Malaysia always facing difficulties to reach fire scene location on short time due to lack of information regarding congestion condition of the roads that connecting to the location. Another problem faced by them is false calls from unknown callers. This study is looking for an alternative solution to overcome the problems by developing a vision based fire recognition system. The system is operated on MATLAB r2013 environment and based on a set of rules developed to identify the value of R, G, B, Y, Cb and Cr component in an image. However, this study scope is limited to fire recognition only. The performance of the system is verified using one hundred images. The images are taken during morning, afternoon and evening to ensure the system is robust to different surrounding brightness. However, the images will undergo several steps of pre-processing to minimize noises. Experimental results show that the both color spaces, RGB and YCbCr have high detection rate of fire which is 90% and 100% respectively. YCbCr color space shows the best performance compared to RGB because it can separate luminance from chrominance more effectively than RGB color space.

Keywords: fire recognition, image processing, RGB, YCbCr color space.

INTRODUCTION

A vision-based fire surveillance system is a system developed to take care of any area or spaces and for a place that our eyes are limited. Instead of using a lot of man powers to guard the area, it could be reduced by using a surveillance system. It was easy to install and inexpensive. However, vision-based system also has some limitations in recognizing fire due to the brightness of surrounding, especially in a daylight condition. At night, fire is rarely been misjudge because it has the brightest image pixels and it is much easier to be detected. The false fire alarm detection could be reduced in many ways, for examples by using Gaussian Rules, Blob detection, and also pixel color determination. In this project, the RGB and YCbCr color components of an image will be analyzed to determine whether there exists any fire or not. The advantage of YCbCr color space is that it can separate luminance from chrominance more effectively compare to RGB color space. Luminance in image is actually a light intensity or the amount of light ranges from black to white. While chrominance is a light wave with color Cyan Red and Cyan Blue.

Vision system

Generally, vision-based system that is using camera provides bountiful information and more reliable compared to a system that is using another sensors such as temperature sensor, smoke detector etc. [1]. Besides, image processing method is a low cost since the algorithm is cheap in computation [2]. Image processing consists of six stages. The first stage is image acquisition that is where the surrounding is captured using a web camera which is directly connected to a computer. Then, the image is undergoes pre-processing stage. In this stage the image is corrected and enhanced to remove noises using image filtering, image restoration and color processing techniques. Third stage is image processing which will separate background from the foreground object, edge detection, morphological processing and image partition. The fourth stage is feature extraction, where the pixels of each desired features are grouped together. This information then will lead to step five which is object classification. Lastly, the decision is made based on test and the analysis, this sixth step is known as classification decision.

Fire recognition methods

Fire detection is accomplished in many ways, such as using temperature sampling, particle sampling, humidity sampling, air transparency testing and also smoke analysis [3]. However, these techniques are not reliable as they cannot provide further information such as fire location, size of fire, growing rate of fire and other information that could give the exact view of the fire scene. Thus, the techniques might results in false alarm because the techniques can miss judge the energy emission of non-fire or by products of combustion. Then, in image processing analysis, the object is detected by looking the color which is motivated by two main factors. First, color simplifies object identification and extraction from a scene. Secondly, human can discern thousands of colour shades and intensities, compared to about only two dozen shades of grey. From the idea of how human interpret an image based on colour, analysis of object based in its colour can be done by understanding the colour fundamental and model [4]. There are many types of color model such as RGB, CMYK, YCbCr, YUV, HSL, HSV, HIS and CIE La*b*. However, each of color spaces has their advantages and disadvantages as can be referred in [4].

METHODOLOGY

The purpose of image processing can be categorizes into five groups which are first is for visualization that is use to observe the object that are not visible. Second, image sharpening and restoration for better image, third is image retrieval to find image of interest. Fourth, measurement of pattern to measures various objects in image and fifth is image recognition to detect target objects in an image. This method is cheap in computational. Figure-1 shows the process flow of developed fire recognition system.

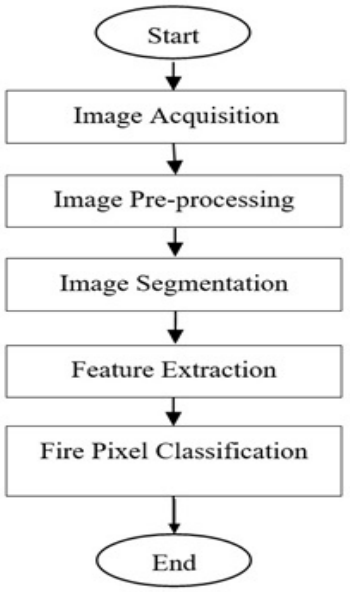

Figure-1. Process flow of fire recognition system.

Image acquisition

This step involved camera and transfers into computers to receive the image in its digital format. Image format used is JPG image compression standard with 8 Mega Pixel resolutions. The data will be collected in a day light which is morning, afternoon and evening. More data will be collected for a better performance system in 100 sample images. A fire will be set up so that the data could be collected.

Image pre-processing

Pre-processing of the digital image is a step to make improvement and enhancement to the image, making sure all the noise is removed prior to processing step. In pre-processing, image filtering, image restoration and/or colour processing are done. This project used RGB and YCbCr colour space. In order to detect fire, pixel of fire region in RGB is explored. Then for YCbCr colour space, the image from RGB format has to be converted to YCbCr format before the image could be analyze. The formula for RGB to YCbCr conversion is as shown in Figure-2 below. Image pre-processing will increase the reliability of optical inspection and recognizing the region of interest.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.2568 & 0.5041 & 0.0979 \\ -0.1482 & -0.2910 & 0.4392 \\ 0.4392 & -0.3678 & -0.0714 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix}$$

Figure-2. Formula conversion of RGB to YCbCr.

Image segmentation

Image segmentation is a further step to separate the background from the foreground object in the image. Lots of image segmentation techniques can be used here such as compression, morphological processing, edge detection and many more advance techniques. This is the hardest part in digital image processing since it involves segmentation procedures to partition the image into the objects desired.

Next, the purpose of thresholding is to extract the objects from the background by selecting the best threshold value for the image. In order to differentiate between background and fire, the process will include segmentation of the fire region and thresholding which value can be found using colour thresholding tools in MATLAB. In this process, histogram plays an important role to find the best threshold value. RGB and YCbCr both have different threshold value of fire region. The specific range and pixel value to be classified as fire in RGB and YCbCr color space is highlighted. Then, the most important step will proceed which is feature extraction. Whereby, all the data and threshold value will be used to create rules for fire recognition.

Feature extraction

Feature extraction is where all the data pixels that represent and describe the desired pixels is been grouped. The set of features will extract relevant information accordingly to the desired task. For this project, fire pixel had been extracted by using two colour spaces and seven rules that were applied for each of image tested. The rules are listed in Table-1.

Table-1. Seven rules for fire recognition.

Color space	Rules
RGB	1) R> G >B
	2) if R> Rmean ∩ G> Gmean ∩ B< Bmean
YCbCr	3) Y(x,y) >= Cb(x,y)
	4) Cr(x,y) >= Cb(x,y
	5) Y(x,y) ≥ Ymean ∩ Cb(x,y) ≤ Cbmean ∩ Cr(x,y) ≥ Crmean
	6) Cb(x,y) – Cr(x,y) ≥ Th
	7) (Cb(x,y) ≤ 120) ∩ (Cr(x,y) ≥ 150)

Each of the rules constructed according to the analysis of 100 sample images. For example, for the Rule 1 and Rule 2, all fire images show that R is the major component in a fire image. However, the R color component reduces significantly during afternoon because of strong sunlight. To overcome this problem, average value of R, G and B was determined based on 100 images used in this work. The average of R component in a fire

image are listed in Table-2. Hence, generally we can classify that the fire region component R should be greater than G and G should be greater than B component.

Table-2. Range for fire region in different conditions.

Daylight	Range R	Range G	Range B
Morning	> 230	> 160	> 50
Afternoon	> 180	> 70	> 100
Evening	> 230	> 100	> 40

While from mean value of YCbCr shows the value Y is greater than Cb and Cr is greater than Cb. The mean value for Y, Cb and Cr are calculated as Equation (1), (2) and (3).

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

$$Cb_{mean}(x,y) = \frac{1}{M \times N} \sum_{X=1}^{M} \sum_{Y=1}^{N} Cb(x,y) \quad (2)$$

$$Cr_{mean}(x,y) = \frac{1}{M \times N} \sum_{X=1}^{M} \sum_{Y=1}^{N} Cr(x,y) \quad (3)$$

Fire pixel classification

In this stage, detection of fire in RGB and YCbCr color space will be combined together for the result to be accurate. That is meant that the image should fulfil all the 7 rules to be considered as fire. In this stage, the output supposed to show the fire region in binary image as if the fire detected. Else, only full black colored image will be displayed.

RESULTS

Analysis on color space

The analysis is to decide which colour space (RGB, Grayscale, YCbCr) is suitable to be used in the system. For this experiment, both RGB and YCbCr color space higher fire detection rate and low false alarm rate. However, YCbCr color space provide more advantage compare to RGB color space as YCbCr can separate the luminance from chrominance more effectively. While for grayscale, the results for both color space RGB and grayscale are same. Grayscale is suitable to be used in the case of high or low light intensity and brightness. In grayscale, plane R, G, and B will have same value. RGB and grayscale able to detect fire, but they cannot differentiate between fire and non-fire object. Figure-3 below shows the results for fire detection using RGB, grayscale and YCbCr color space.

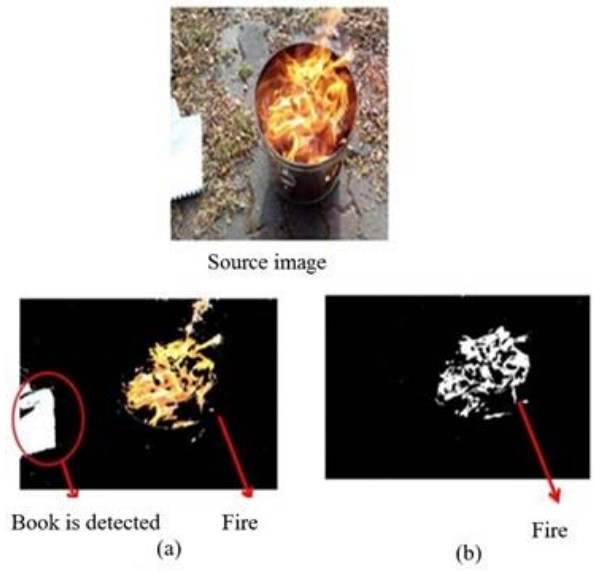

Figure-3. Comparison of two color spaces in recognizing fire (a) RGB (b) YCbCr.

YCbCr color space is the compression of half RGB pixel values. The color pixel in YCbCr will reduce from its original pixel values (255 until 127). Reduction of pixel values in YCbCr enable it to detect the fire efficiently because the range of each color and noise had been reduced. In this experiment, tests have been done during day light, so the fire and its surrounding will be influenced by the luminance and chrominance effect. Both color spaces can be used to detect fire, but YCbCr color space is more suitable to deal with environment in daylight. Further explanation can be form in the next analysis.

Analysis on fire detection process (image processing)

In order to detect fire, all color components of the two color spaces must be determined, cannot only depending on RGB color space. This is to prevent from false alarm the fire recognition. Therefore, a rule which consist of seven rules had been constructed for classification of a pixel classified as fire. If a pixel satisfies these seven rules, the pixels belong to fire class. About 100 images are used to determine fire characteristics.

DISCUSSION

RGB not accurately detect the fire by itself and it must combining with YCbCr color space to get the more accurate detection rate. The figure 4 and 5 shows the result for each of rules which is combined the RGB and YCbCr.

Figure-6 and Figure-7 show the experimental result for input and output with combination of all rules produce the corresponding fire region from input images. For performance evaluation, a test on 100 sample images is been carried out which consists 90 fire images and 10 non fire images. The detection rate of fire for YCbCr is greater than RGB which is 100% in YCbCr compare 90% in RGB. RGB is facing problems with things that have

same fire pixel such as shining and reflected things in surrounding. Besides, the uses of YCbCr to separate luminance and chrominance more effectively than RGB.

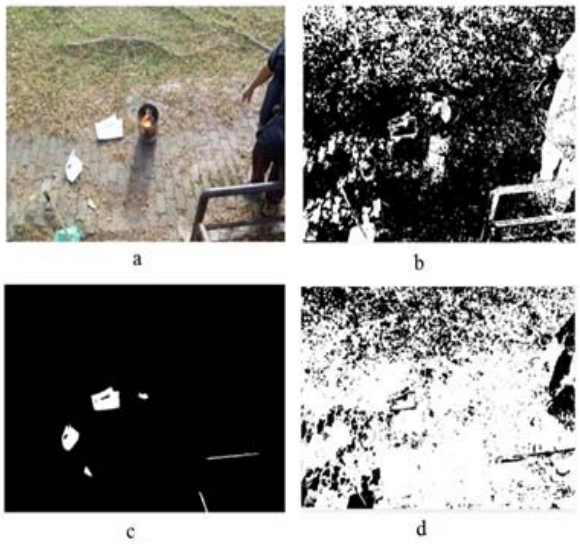

Figure-4. Detection of fire in static image. (a) original image (b) fire segmented using rule 1 (C)fire segmented using rule 2(d) fire segmented using rule 3.

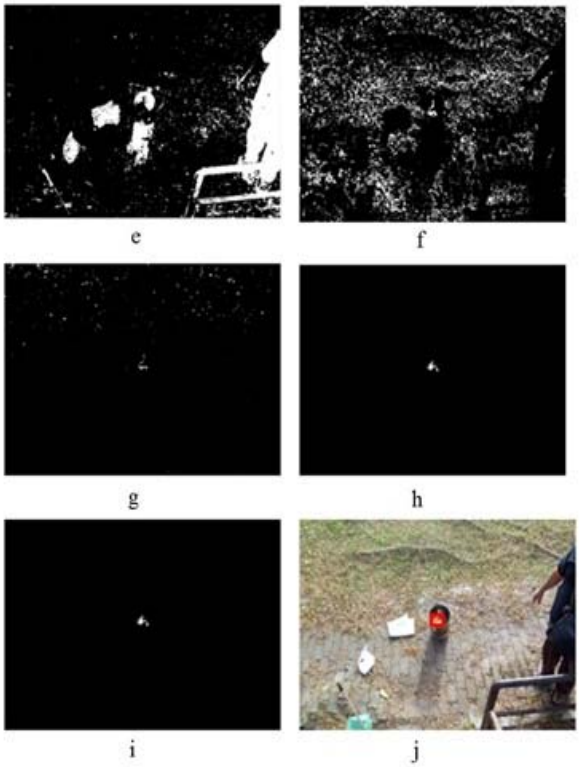

Figure-5. (e) fire segmented using rule 4 (f) fire segmented using rule 5 (g)fire segmented using rule 6 (h) fire segmented using rule 7(i)fire segmented using rule 1-7 (j) result represent.

Figure-6. Experimental results (a)input image (b) output image.

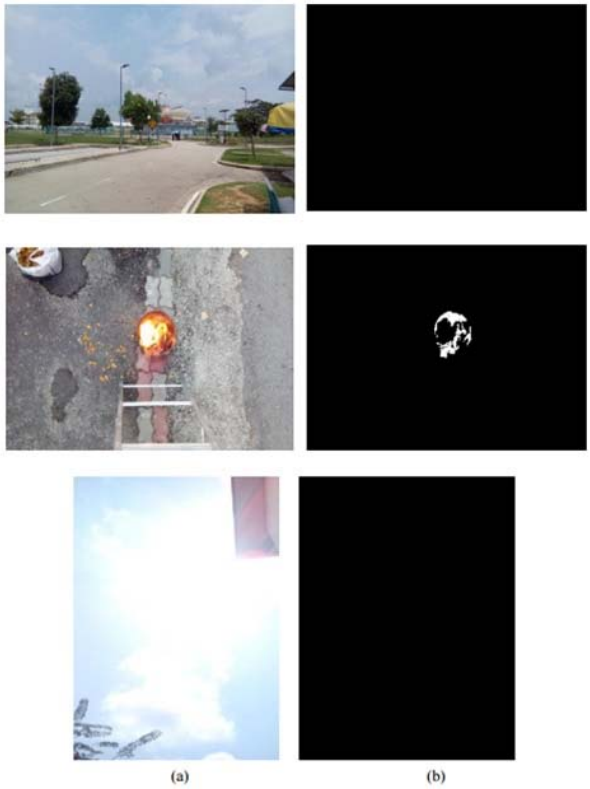

Figure-7. Experimental result (a) input image (b) corresponding output image.

CONCLUSIONS

As a conclusion, the system had successfully recognized fire existence in all three conditions that have been tested based on 100 images. Analysis results show that both colour spaces have higher fire detection rate which is RGB 90% and YCbCr 100% respectively. Both colour spaces can be used to detect fire, but YCbCr colour space has a greater detection rate as to compare to RGB because YCBCr can separate luminance from chrominance more effectively than RGB. The system is able to differentiate the things in surrounding (non-fire) or reflected things that have same value as fire pixel value; false fire alarm could be avoided. Hence, recognition of fire using colour spaces RGB and YCbCr through seven rules for fire pixel classification could establish highly reliable system.

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