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Flame Luminance Enhancement using Chromaticity Pigmentation for Real Time Fire Detection

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***Abstract*—** Fire detection is a technique through which fire or flame can be detected that alarm in crucial situation. Fire should be detected at real time and required action supposed to be taken immediately. Fire can be detected either by physical sensors or image processing. Some, remote area like forest requires real time detection but physical sensor cannot be placed at well that image processing is more powerful in such areas. Most of the image based recognition technique is processed through flame color detection. Flame color possesses yellow, red and orange that belongs to RGB and CMY color models. Here the proposed system focuses on flame luminance enhancement that increases the color intensity of flame through which fire can be detected with high level of accuracy. Proposed system uses HSL and CMY color models along with chromaticity pigmentation technique that allows to increase particular color intensity for higher true acceptance rate that reduces true rejection rate.

***Keywords*—** Fire Detection, Flame Luminance, Chromaticity Pigmentation, HSL, RGB and CMY color models

I. INTRODUCTION

Fire Detection is a process of confirming phenomena related to fire; that can be detected either by a physical sensor or image processing. It can be detected through –

- Smoke
- Heat
- Infrared or Ultraviolet light radiation or Gas
- Color luminance

Figure 1. Fire Detection Sensors [1]

Figure 2. Image Processing based Fire Detection [2]

Figure 3. Forest or Remote Area Hazards [3]

Physical sensors are not suitable for remote areas like forest, because the area is bit larger to cover and alarm system require so many sensors over there that cannot be easily manageable from control room. For this image processing approach is far better than fire detectors. It can cover large area and only few cameras are required to get alarm at real time that can be managed easily as compare to the physical sensors.

II. Related Work

Angelo Gonzalez et al. proposed a method by inducing Convolutional Neural Network to detect fire in the shown images. The approach used was SFEwAN-SD (Simple Feature Extraction with FCN AlexNet, Single Deconvolution). The system which has been proposed is a fraction of Unmanned Autonomous Vehicle (UAV) system which was used to detect and examine wildfire [4]. Shruti Gupta et al. proposed a system to detect any calamity by exploiting the functionality of WSN i.e. wireless sensor networks. The system further have used an algorithm of LEACH i.e. Low Energy Adaptive Clustering Hierarchy to sustain the communication among the defined nodes [5]. Kuang-Pen Chou et al. developed a system which exploited feature extraction method which is based on blocks to examine the local data of assorted regions to reduce computational data. System relied on the concept to extract the features obtained from a fire block including its color, source immobility and its disorder [6]. Rubayat Ahmed Khan et al. proposed a system base on the technique of video processing. System extracted various features like color and spatiotemporal characteristics to recognize the area of fire [7]. Teng Wang et al. proposed a system for indoor detection of fire by incorporated the characteristics of flame kinematics which was induced on the consecutively extracted video frames. Resemblances obtained from acquired video frames were also integrated in the system which has been proposed [8]. Nurul Shakira Bakri et al. proposed a system which exploited the technique of image processing to classify the pixels of color. Technique which has been proposed in the system considered fire images as an input [9]. Oxsy Giandi et al. developed a technique in a system called fire predictor and fire appearance detector. In the system which has been proposed, fuzzy system technique was employed on fire detector and fire predictor illustrated the concentration of gas leak & generates an alarm on emergency [10]. Khan Muhammad et al. proposed a system based on images to detect fire by exploiting the technique of CNN (convolutional neural networks). The system which has been proposed in the paper relied on the basic idea of Google Net architecture. System utilized the deep learning architecture to detect flames as early as possible [11]. But color based detection can be affected by light or bright luminance that increases the rate of true rejection as well as false acceptance. Conversion rate is bit lower as it required.

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

Formula for RGB to YCbCr colour space conversion. Accuracy is enhanced up to 90%.

Figure 4. Original Image that later enhanced with previously proposed system [4]

Figure 5. Contrasted Enhanced Image by previously proposed system [4]

The enhancement level is poor and not effective for real time fire detection. It does not increases the fire color intensity through which it can be detected with high level of accuracy.

III. PROPOSED WORD & METHODOLOGY

Proposed work is able to detect fire with high level of accuracy. System can enhance flame luminance using Chromaticity Pigmentation. System changes the intensity of flame color to its peak level where it can be classified easily with minimal false alarm rate. System uses three color models for enhancement i.e. RGB (Red Green Blue), CMY (Cyan Magenta Yellow) and HSL (Hue Saturation Lightness).

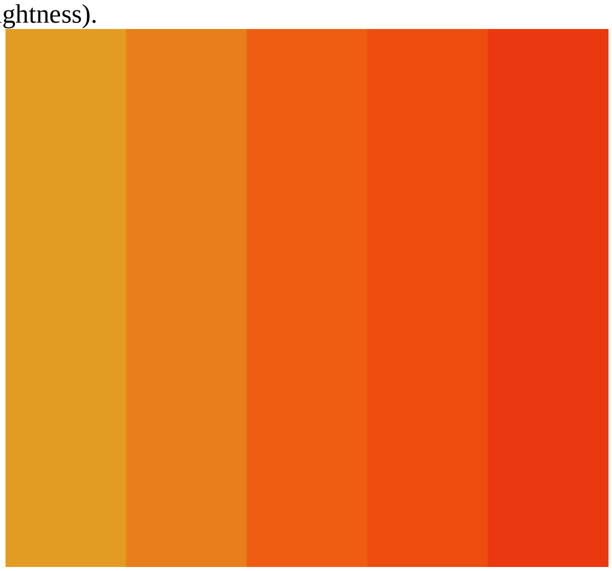


Figure 6. Color Model of Flame

System converts RGB (Red Green Blue) color model to HSL (Hue Saturation Lightness) for brighten flame luminance and later to CMY color model that enhances yellow intensity.

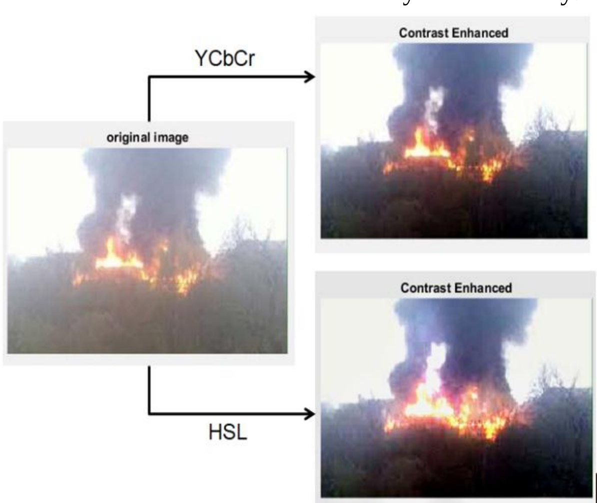


Figure 7. YCbCr v/s HSL Color model

If flame is intended to increased by chromaticity pigmentation that enhances the probability of true recognition instead of true rejection or true negative, but false recognition may rises because of high flame intensity but it does not any cost. Fire detection is required at any how because it may increases the causalities.

Figure 8. Original Image that possess low flame intensity

In fig 8, flame intensity is low which may traverse true rejection or true negative. But proposed system is able to enhance the flame color intensity that increases the accuracy rate and fire can be detected with high level of accuracy.

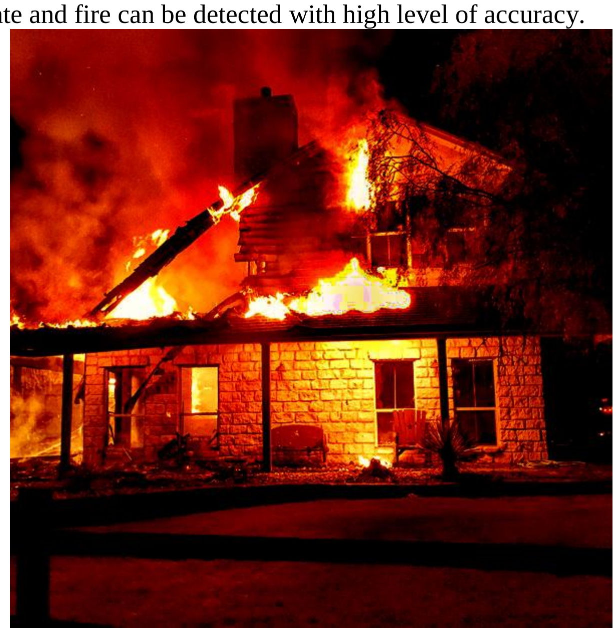


Figure 9. High Flame Intensity

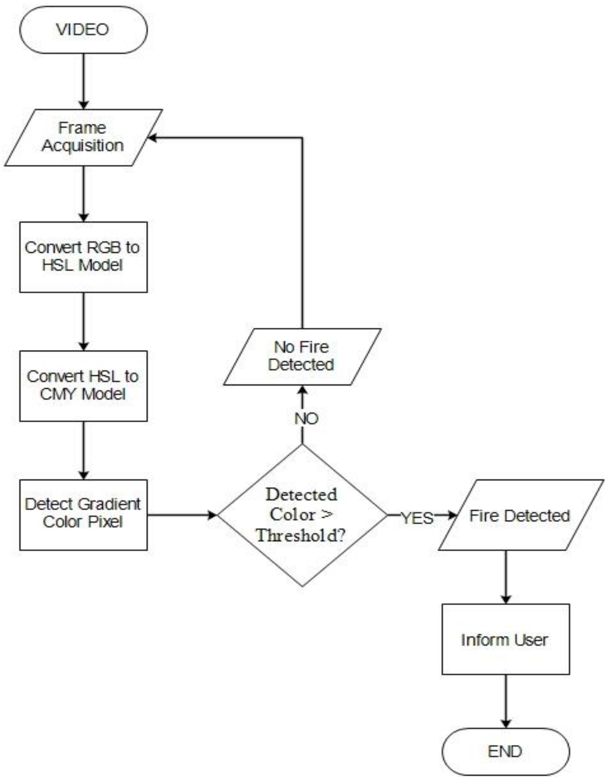


Figure 10. Flow Chart

As per the flow chart, first of all a frame is acquired from video for further processing, once it has been acquired; color model has been applied i.e. RGB to HSL which increases the lightness of the flame and pertain high intensity values, then again HSL to CMY which increases the yellowness of the flame that definitely enhances the accuracy level. Once the conversion has been done, a gradient color has been visible to the image and it will further validate with threshold value, if it is greater than threshold value, it means that there is fire and it should be detected and indeed it acquired else it will again acquire another frame from video and a loop process proceed with all steps.

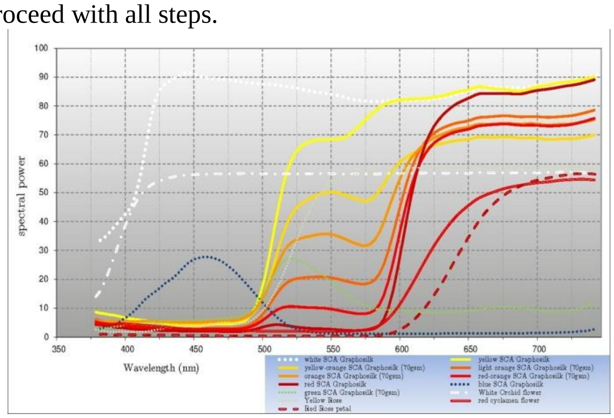


Figure 11. Fire Color Model

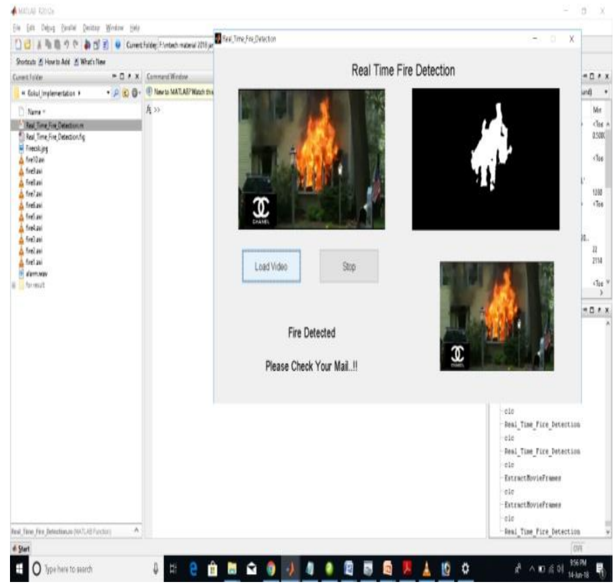


Figure 12. Proposed Work

Here, the system is based on chromaticity pigmentation that allows increasing particular color intensity for better recognition rate. As a human can easily recognizes color and its shade or fire, similarly chromaticity pigmentation enhances color level to human visibility. Proposed system is based on mainly two color models i.e. HSL (Hue Saturation Lightness) and CMY (Cyan Magenta Yellow).

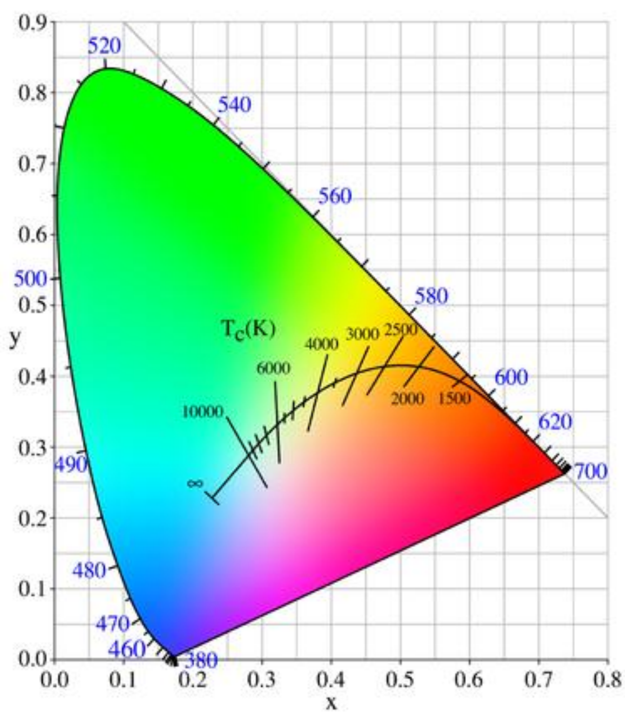


Figure 13. Chromaticity Pigmentation

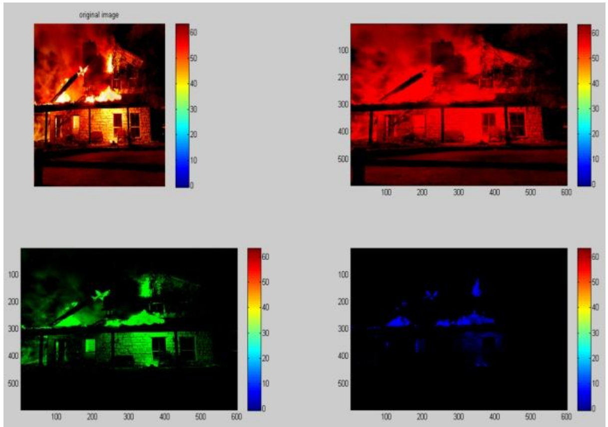


Figure 14. RGB Color Model

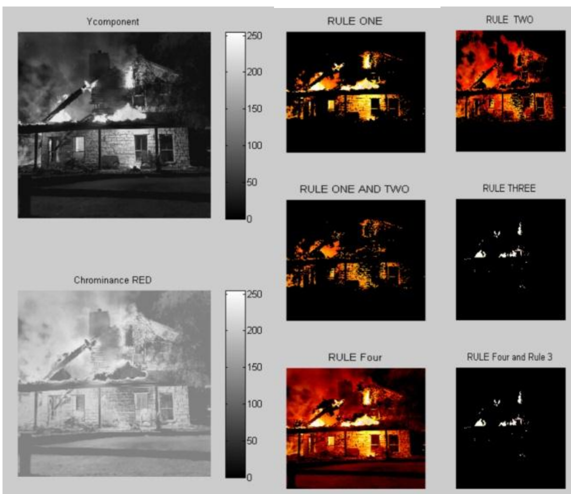


Figure 15. HSV & CMY Color Model

Flame Chromaticity Pigmentation (FCP) Algorithm -
Require: Input frame I, Threshold Value ΔT, Acquired Color Model M, HSL Color Model C_1, CMY Color Model C_2, and Last Frame N.
Input: Current Frame I
Output: Color Detected Frame R
Step 1: Acquire Current Frame I

Step 2: Apply RGB to HSL color model

$$\begin{bmatrix} H \\ S \\ L \end{bmatrix} = \begin{bmatrix} 0.3958 & 0.6911 & 0.0485 \\ -0.1971 & -0.3239 & 0.4480 \\ 0.3728 & -0.2989 & -0.0985 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 0.299 \\ 0.587 \\ 0.114 \end{bmatrix}$$

Write new frame [I_1]

Step 3: Apply HSL to CMY color model

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 0.2568 & 0.5401 & 0.0979 \\ -0.1482 & -0.2910 & 0.4392 \\ 0.4392 & -0.3678 & -0.0714 \end{bmatrix} \begin{bmatrix} H \\ S \\ L \end{bmatrix} + \begin{bmatrix} 165 \\ 45 \\ 90 \end{bmatrix}$$

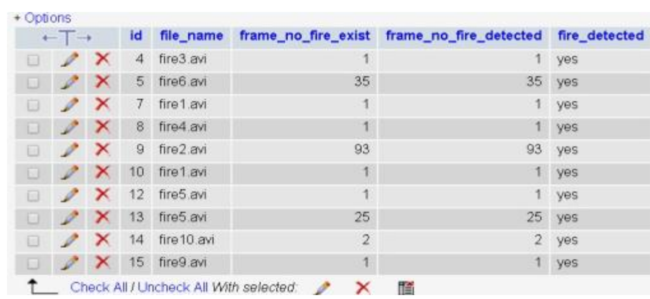
Write new frame [I_2]

Step 4: While I ≠ N **do**
If $I_2 > \Delta T$ **then**//Threshold value relies Yellow & Orange HEX color
Fire Detected;
else
No Fire Detected;
end else
end if
end while
Step 5: End

IV. RESULTS AND DISCUSSION

Table 1 Result Analysis

S.No.	File Name	Frame No. that Fire Exist	Frame No. that Fire Detected	Result
1	Fire1.avi	1	1	Fire Detected
2	Fire2.avi	93	93	Fire Detected
3	Fire3.avi	1	1	Fire Detected
4	Fire4.avi	1	1	Fire Detected
5	Fire5.avi	1	1	Fire Detected
6	Fire6.avi	35	35	Fire Detected
7	Fire7.avi	12	12	Fire Detected
8	Fire8.avi	118	118	Fire Detected
9	Fire9.avi	1	1	Fire Detected
10	Fire10.avi	2	2	Fire Detected



+ Options

id	file_name	frame_no_fire_exist	frame_no_fire_detected	fire_detected
4	fire3.avi	1	1	yes
5	fire6.avi	35	35	yes
7	fire1.avi	1	1	yes
8	fire4.avi	1	1	yes
9	fire2.avi	93	93	yes
10	fire1.avi	1	1	yes
12	fire5.avi	1	1	yes
13	fire5.avi	25	25	yes
14	fire10.avi	2	2	yes
15	fire9.avi	1	1	yes

Check All / Uncheck All With selected:

Figure 16. Result Simulation

Table 2 Result Comparison

SCEME	PRESENT	PROPOSED
No. of frames tested	10	10
No. of frames that contains flame	10	10
No. of frames where flame detected	9	10
No. of frames where flame not detected	1	0
True Positive	9	10
True Negative	1	0
False Positive	0	0
Overall Accuracy	90%	100% (Over 10 Frames)
		95% (Over 2 Frames)

$$Accuracy = \frac{Total\ no.of\ Frames - (True\ Negative + False\ Positive)}{Total\ no.of\ Frames} * 100\ \%$$

$$Accuracy = \frac{20 - (0 + 1)}{20} * 100\ \%$$

$$Accuracy = \frac{19}{20} * 100\ \%$$

$$Accuracy = 95\ \%$$

Result calculation is based over 20 frames where 0 true negative and 1 false positive have been recognized. So, overall accuracy is 95 %

V. CONCLUSION AND FUTURE SCOPE

The current proposed system is able to enhance flame luminance using chromaticity pigmentation that also enhances the accuracy or true acceptance rate. It increases the specific color pixel that relies flame intensity which provides better level of accuracy. The current proposed concept of enhancing flame luminance using chromaticity pigmentation can be implemented for detection of fire based calamities which would be effective for remote areas as well as indoor hazardous accidents.

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