Image processing based fire detection system(IOT)

Abstract- Traditional fire detection system use different types of physical sensor for the fire detection but these are slow and less efficient leads to great loss of both money and life .To overcome such problem this projects propose a fire detection system based on image processing which uses the RGB,CIELab ,YCbCr colorspace for fire color modelling and moving pixel detection method to reduce false warning.This project uses the IOT techniques to instantly warn the recipient on the mobile by SMS/MMS.

I. Introduction:

Fire is dangerous that could bring great loss for human life, especially fire in buildings, can spread quickly and cause great loss of life and property.

The National Crime Records Bureau Of India Data indicates that a total of 113961 people lost their lives due to Fire Accidents from 2010 to 2014. This is an average of 62 deaths a day. Maharashtra alone accounted for 24293 deaths or 21.3% of all the deaths due to fire accidents.Fire Accidents caused an average of 62 deaths per day in the last 5 years [1].

To prevent these losses various alarm system has been developed, but these system doesn't proved too helpful and have certain disadvantages listed below.

- Fire detectors, smoke detectors and temperature detectors have been mostly used to protect property and give warning of fires. However, smoke and temperature detection is slower than light detection.
- More number of sensor are required to cover whole area.
- They will give warning after a threshold rise in temperature ,and this may lead to loss in property.
- These conventional systems are not smart and intelligent.
- Cost is high and they are prone to damage by dust and have less life time.

Due to fast developments in digital camera technology and video processing techniques, computer vision technologies, IoT(Internet of Things) technologies ,we were able to create smart, efficient, intelligent system .There is a major trend to replace conventional fire detection methods with computer vision based systems.

A good color model for fire modeling and robust moving pixel segmentation are essential because of their critical role in computer vision-based fire detection systems. In this paper, we propose an algorithm that models the fire pixels using the CIEL*a*b* color space. The motivation for using CIE L *a *b *color space is because it is perceptually uniform color space, thus making it possible to represent color information of fire better than other color spaces. The moving pixels are detected by applying a background subtraction algorithm together with a frame differencing algorithm on the frame buffer filled with consecutive frames of input video to separate the moving pixels from non-moving pixels. The moving pixels which are also detected as a fire pixel are further analyzed in consecutive frames to raise a fire alarm.

This report is organised into four section : Section II describes related work and reviews previous works; Section III presents our proposed system in detail;Section IV describes the Conclusion;Section V has the information about the references.

II. Related Works :

- Wenhao and Hong [2] extracted flame objects by iterative adaptive threshold techniques, and then used fire flame color as a part of characteristic information analysis to detect fire.
- Celik and Demirel [3] used YCbCr colors space to separate luminance from chrominance. It is possible for a false detection if only color characteristics have been used.
- Celik [4] divides the proposed algorithm into two parts, which are fire color modelling and motion detection. The color modelling part usesCIE L*a*b* color space. The motion detection parts uses frame/background subtraction, background registration, and moving pixel detection.
- Sarita and Ajay[5] used switches as well as Temperature & IR Sensors are placed at appropriate locations in building to determine fire-happening then Wireless communication is made possible by RF module, If fire is detected then micro-controller are used to calculate fire affected area and quantity of extinguisher required by preset data. This information and URL address of affected location is send to fire control office by GSM module. GOOGLE MAP is used to trace the affected location and timely rescue operation is made possible.

Literature Review

Author Name	Year	Methodology used
1) Xian-Feng Han	2017	RGB, HSI and YUV color space and Gaussian Mixture Model-based background subtraction
2) Jae-Hyun Jun	2017	Multichannel information and gray level co-occurrence matrix (GLCM) image features. Multi-channels consist of RGB, YCbCr, and HSV color spaces.
3) Yang Jia	2015	SVM-based flame and non-flame class-action
4) Mongkol Ekpanyapong	2015	RGB color filter and motion detection by optical flow
5) Yang Hao	2014	The Canny edge detection algorithm
6) Lee Soon	2013	Infrared image based smart fire detection
7) Hou Rongqin	2008	Multi-frequency image color, black and white and the near infrared rays, the color/ monochrome,color / dual variable near-infrared camera.
8) Billy Hou	2008	Integration of multi-wavelength smoke and flame detection algorithms and fire data fusion algorithm
9) Li Hongyun	2009	Multi-band infrared image

III. Proposed System

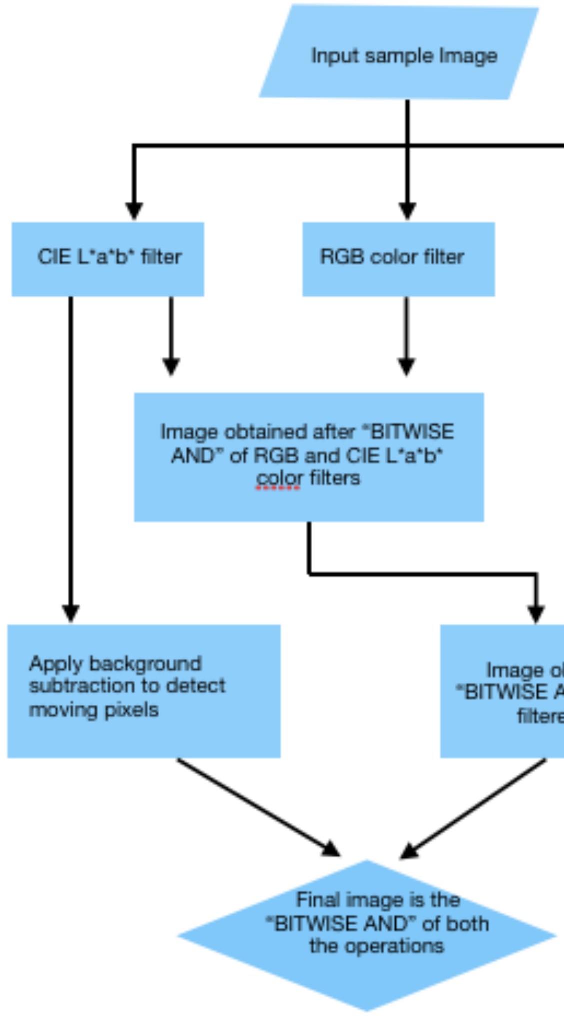

Fig. 1. Flow chart of proposed algorithm for fire detection in image

Color Modelling for Fire Detection:

1. RGB FILTER:

Before applying our algorithm we have to convert BGR colorspace to RGB colourspace.In RGB colourspace we apply the following condition to identify the desired binary image B4.

B1(x,y)=R(x,y)>G(x,y)
B2(x,y)=G(x,y)>B(x,y)
B3=R(x,y)>Rth
B4=B1⊗B2⊗B3

(x,y) represent the spatial pixel location in an imaging grid.

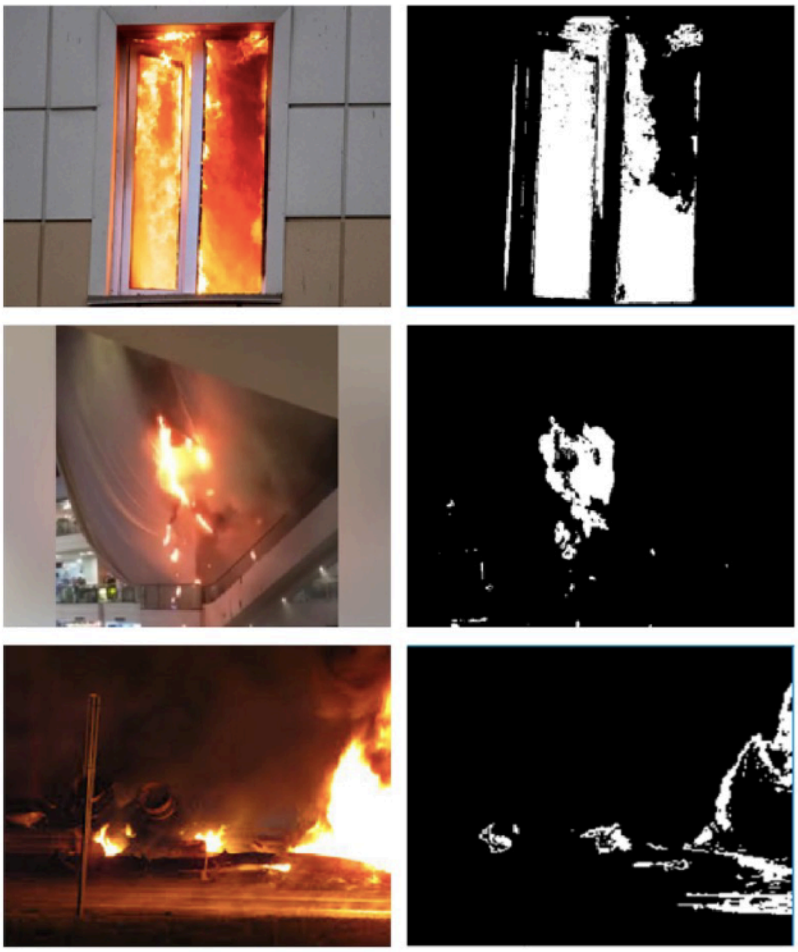

Fig.2. Sample images containing fire and their results after applying RGB filter

2. CIE LAB FILTER:

CIE LAB colorspace expresses color as three numerical values, ***L**** for the lightness and ***a**** and ***b**** for the green–red and blue–yellow color components. CIELAB was designed to be **perceptually uniform** with respect to human color vision, meaning that the same amount of numerical change in these values corresponds to about the same amount of visually perceived change.
On the analysis of L* ,a*,b* colourspace the desired fire pixel can be filteredout by applying the following conditions.

$$R1(x,y)=\begin{cases}1, & \text{if } L^*(x,y)\geq L_m^*,\\ 0, & \text{otherwise,}\end{cases}$$

$$R2(x,y)=\begin{cases}1, & \text{if } a^*(x,y)\geq a_m^*,\\ 0, & \text{otherwise,}\end{cases}$$

$$R3(x,y)=\begin{cases}1, & \text{if } b^*(x,y)\geq b_m^*,\\ 0, & \text{otherwise,}\end{cases}$$

$$R4(x,y)=\begin{cases}1, & \text{if } b^*(x,y)\geq a^*(x,y),\\ 0, & \text{otherwise,}\end{cases}$$

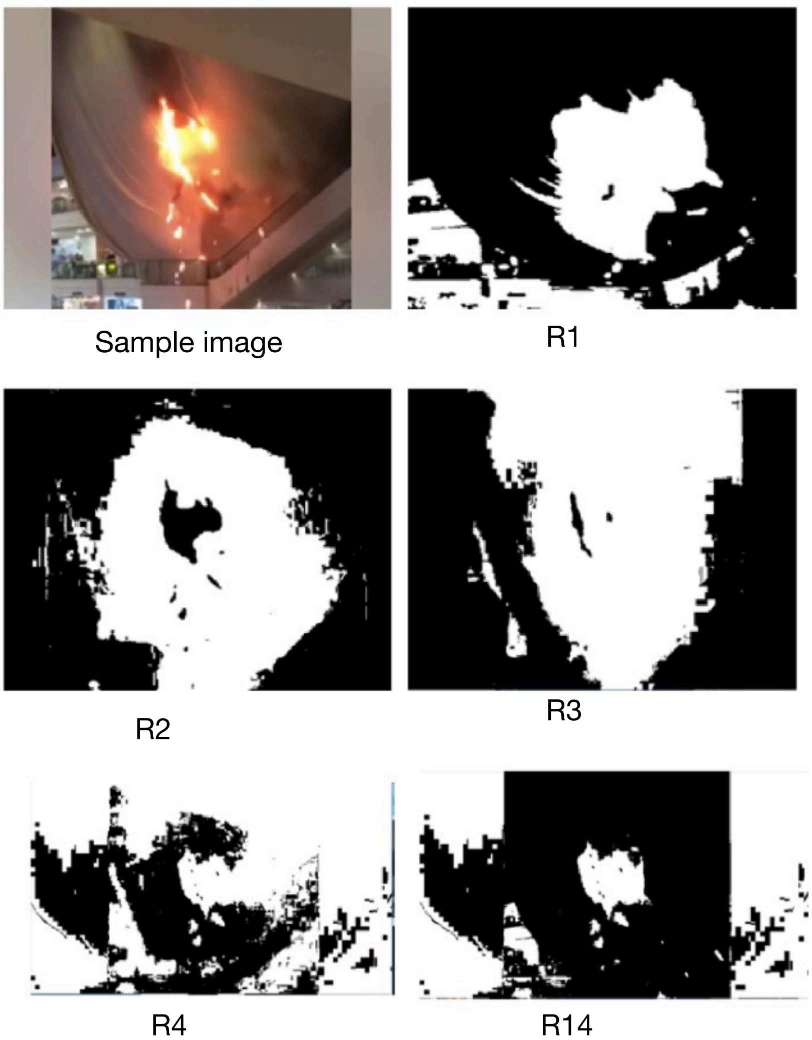

Fig.3.1. Sample images containing fire and their CIE L*a*b* colour channels, if we see these binary images then we can infer that R14 is the 'BINARY AND' of R1 and R4 (i.e. R14=R1^R4) .

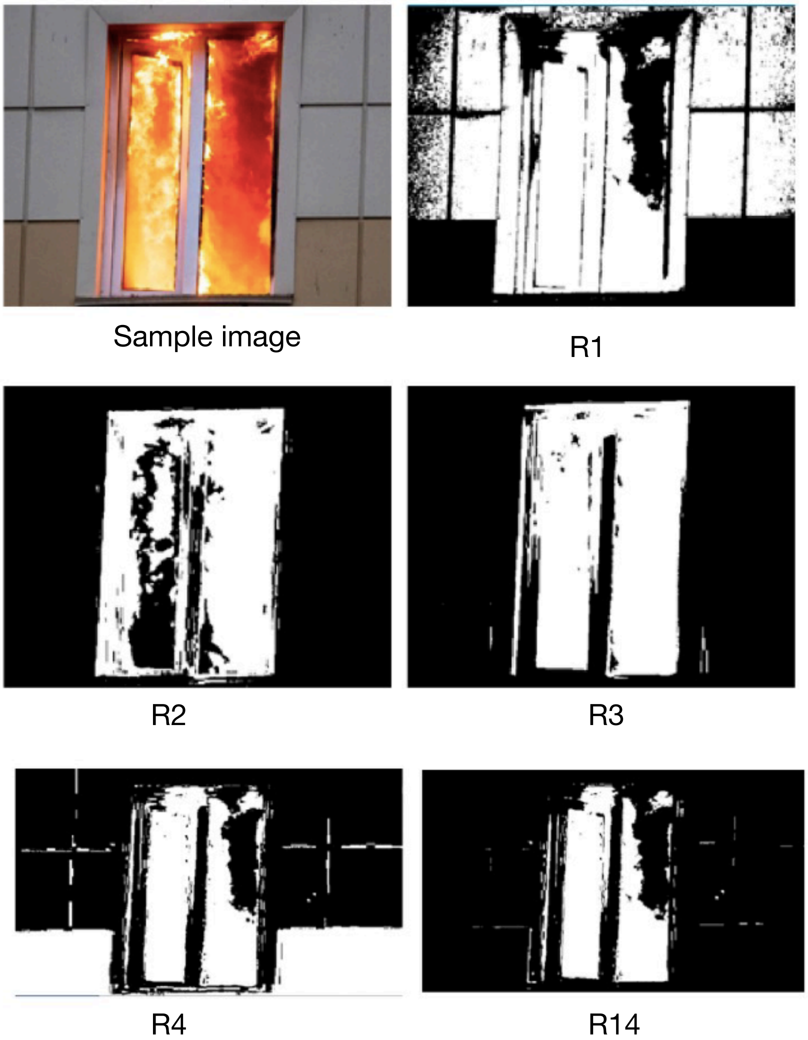

Fig.3.2. Sample images containing fire and their CIE L*a*b* colour channels, if we see these binary images then we can infer that R14 is the 'BINARY AND' of R1 and R4 (i.e. R14=R1^R4) .

3. YCbCr color space filter:

In YCbCr color space, Y′ is the luma component (the "black and white" or achromatic portion of the image) and Cb and Cr. are the blue-difference and red-difference chrominance components, will be chosen intentionally because of its ability to separate illumination information from chrominance more effectively than the other color spaces. In YCbCr color space and analysis can be performed. For a fire pixel Y(x, y) >= Cr(x, y) >= Cb(x, y), where a non-fire pixels don't satisfy this condition, where (x,y) is spatial location of a fire pixel. Such system can be useful for detecting forest fires where we can't put sensors at each location. So we can summarise overall relation between Y(x, y), Cb(x, y) and Cr(x, y) as follows:

$$R = \begin{cases} 1, & if \left| Cb(x,y) - Cr(x,y) \right| > 70, \\ 0, & otherwise \end{cases}$$

Fig.4. Sample images containing fire and their results after applying YCbCr filter

<u>Final Image</u>

Fig.5. Final image (i.e. the “BINARY AND” of all the images obtain by the applied colour filters)

<u>Moving Pixel Detection</u>

In moving pixel detection, it is assumed that the video camera is stable, that is, the camera is still, and there is no movement in spatial location of the video camera.

The following steps are followed to detect the moving fire pixel.

- Computation of the binary frame difference map by thresholding the difference between two consecutive input frames.
- Computation of binary background difference map is generated by comparing the current input frame with the background frame stored in the background buffer simultaneously with above mentioned step.

- According to the frame difference map of past several frames, pixels which are not moving for a long time are considered as reliable background in the background registration .

The binary background difference map and the binary frame difference map are used together to create the binary moving pixel map.

Final candidate fire pixel is the binary AND of all binary maps obtained by applying different fire modelling algorithms and moving binary map.

Calculation of Factor deciding the triggering of alarm:

The no of pixel NP(t) are counted in the candidate fire pixel and a counter CO(t) is maintained satisfying the following conditions.

$$CO(t) = \left\{ \begin{array}{ll} \boldsymbol{CO(t-1)+1}, & \boldsymbol{NO(t) > NO(t-1)} \\ \boldsymbol{CO(t-1)}, & \boldsymbol{otherwise} \end{array} \right\}$$

To remove dependency of alarm triggering upon the frame rate of video the deciding factor D(t) is calculated as,

$$D(t) = \frac{CO(t) - CO\left(t - fps + 1\right)}{fps}$$

Where, fps=frame per second of video.

Now, if D(t) >0.3 alarm should be triggered.
The whole method proposed above is implemented for testing purpose in Raspberry pi 3 and the message on mobile in case of fire is shown .

Tests and system performance

The color model is tested on different video sequences of different environmental conditions.The method is applied on each frame of each video after applying all the color filters of proposed algorithm. The results of proposed fire detection method are shown in Table 1 where:-

Ft:- No. of frames of a video sequence

Ff:- No. of frames containing fire in a video sequence

Fc:-No. of frames (including fire and non- fire frames) that correctly classify fire pixels by the proposed algorithm)

FP:-No. of frames classified as false positive (means that the system recognises fire in an image frame when there is no fire)

VIDEO	Ft	Ff	Fc	FP	FN	Rd
1	199	199	199	0	0	100
2	218	218	218	0	0	100
3	443	107	406	30	7	91.46
4	246	246	246	0	0	100
5	398	101	395	0	3	99.24
6	568	247	563	1	14	99.11
TOTAL	2072	1118	2027	31	24	98.31

Table 1. Experimental results of fire detection using color information.

FN:-No. of frames classified as false negative (means that the system does not detect fire in an image frame when there is indeed fire

The detection rate , Rd of a video is defined as:-

$$R_d = \frac{F_c}{F_t}.$$

<u>Result of fire detection system</u>

Fig.6.Final images obtained during testing of fire detection system

The average detection rate that can be achieved is more than 98.31% with the test sequences of samples shown in Table 1. Fig shows sample fire detection results using only color information on different video sequences. It is clear from Table 1 and Fig. 6 that under different conditions, the proposed fire color model can detect fire adequately, which is very important for a robust fire detection system.

CGO(t)	CGO(t-1)	FPS	P(t)
10	0	24	0.4
22	10	24	0.5
32	22	24	0.45
43	32	24	0.41
52	43	24	0.4
64	52	24	0.37
74	64	24	0.41

Table 2.Factor responsible for alert system in sample video 1 is obtained as follows

CGO(t)	CGO(t-1)	FPS	P(t)
21	0	24	0.87
36	21	24	0.62
50	36	24	0.58
61	51	24	0.45
71	61	24	0.41

Table 3.Factor responsible for alert system in sample video 2 is obtained as follows

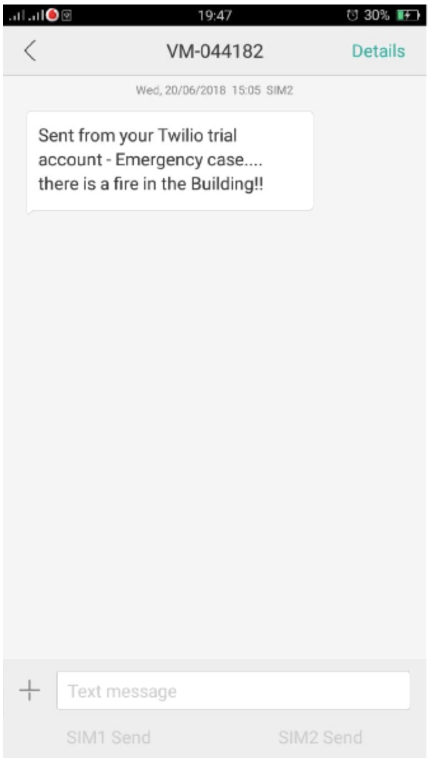

Fig.7. Message on mobile in case of danger

IV. Conclusion:

In this project we found that analysing fire in CIE Lab colorspace yields better results and YCbCr colorspaces are so much helpful in the detection of forest fire.It is difficult to detect the fire in smoky region.

The moving pixel detection part leads the intelligent fire detection system which does not respond to the intentional alarm triggering by some mischievous person wanted to create chaos .
The alert gives fluctuating factor D(t) due to the flickering of fire .
The intregation of system with IOT is so much helpful for the society and is good step in the welfare of mankind which fulfil the main aim the Design and Innovation of IIT BHU.

V. References:

[1].Fire Accidents caused an average of 62 deaths per day in the last 5 years. https://factly.in/fire-accidents-caused-an-average-of-62-deaths-per-day-in-the-last-5-years/

[2]. M. Li, W. Xu, K. Xu, J. Fan, and D. Hou, "Review of fire detection technologies based on video image", JATIT, vol. 49, no. 2, pp. 700-707,Mar. 2013.

[3].T. Celik, and H. Demirel, "Fire detection in video sequences using a generic color model", Fire Safety J, 2008, doi:10.1016/j.firesaf.2008.05.005.

[4].T. Celik, "Fast and efficient method for fire detection using image processing", ETRI Journal, vol. 32, no. 6, pp. 811-890, 2010.

[5].Sarita Gupta ; Ajay Mudgil ; Prashant Bhardwaj ; Mahendra Gupta,"Design and Development of Automatic Fire Alert System",Publication Year: 2016, Page(s):632 - 636