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Enhancing Fire Detection for Indoor and outdoor locations via video surveillance

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Abstract- **Fire is considered as one of the dominant risk affecting everyday life around the world. Traditional way of detecting fire make mostly the use of sensors which sense the fire using fire parameters but the sensors requires certain amount of time to detect the presence of fire. This technique takes more amount of time to detect the fire and till then flames of fire may get converted to the hazardous damage causing fire which leads to huge loss of properties. The solution for problem is to design an efficient system for indoor and outdoor fire detection using video surveillance camera. Identifying fire using the computerized monitoring methods has a significant consideration over the last decade. Still there are additional complexities in deciding whether the region identified as fire is really a fire or not. The judgment behind this is the continuous change in the color of fire from red-yellow to nearly white. To overcome on this, proposed system uses multiple options like motion and shape of fire so that the detection of fire is done in fast way as well as in an accurate manner. Thus the system tries to improve the efficiency of fire detection by using the available resources.**

Keywords- **Video surveillance, Fire Detection, frame differencing, morphology, Fuzzy logic.**

I. INTRODUCTION

The role of fire detection is to detect the presence of fire and set alarm so that immediate action can be taken. Detection of fire can be done in many effective ways but detecting fire quickly with respect to time is very important to avoid the damage causing hazards of fire. So developing a proper system with the available resources is important which could detect the fire instantly and notify it quickly before it causes any serious damage to the life's or property.

With the evaluation of economy, the amount of high buildings is growing with cities. Mostly, for the more convoluted and large populated area, there were high amount of fire and intensive staff, so the considerable property damage and huge disaster like high loss of economy and may be a lot of death will be caused if there is fire in these places, it has a bad social impact. Thus to obtain more valuable time for extinguish and evacuation, difficulty in fire finding and alarm are urgently be solved. In spacious rooms and buildings, traditional fire detectors can hardly detect particular parameters of fire like temperature, smoke, flame, etc in the less time of fire, and cannot meet the demand of early fire detection in these places. Related to conventional fire detectors like sensors, fire detection using surveillance camera which have many advantages, such as quick response, long distance of detection, large protection area, are particularly applicable to large rooms and high buildings. But there are many existing methods having high rates of false alarms for fire detection. Researchers have done a lot of research on this new technique. The main idea of fire detection using video surveillance occurs from other methods of fire detection like sensors. Sensors always need high deployment and maintenance cost.

Fire has some frequent attributes like every other object. These unique attributes in fire are needed to be identified to detect the presence of fire. These attributes includes the shape, motion, growth in area of fire [12], spectral, chronological attributes etc. If the system identifies all these set of attributes then it notifies very easily about the presence of fire and along with this it also tells about the various characteristics of the fire which includes: temperature of fire, elements which have caused the fire which can be identified by its color. Similarly motion of fire also has unique features i.e. it will not remain stable for a sequence[10], [11] of frame. As if the motion of fire is varying continuously for a sequence of frame then the area under fire is increasing [12] and it can be said that fire could be a damage causing fire. While if the ratio is not varying to a great extent then it might be the presence of the stable flame instead of the hazardous fire which is not dangerous for environment like flame of the candle. Similarly there are various other properties of fire which gives unique and useful information related to detection of fire. Thus considering all these, there is a need to develop the multiexpert system [13] which takes into consideration most of the above useful attributes for fire detection.

The proposed system processes visual information captured through immovable camera that lets us assimilate the techniques to CCTV surveillance system, as a result does not require an additional extension on typical fire sensors and it is always having proneness of producing wrong alerts. Using single fire feature it is difficult to give right alarm, so to overcome on this limitation it is better to use multiple features of fire as done in[5]. There are different algorithms for concluding output like Super Vector Machine, Multi Expert System, etc, but they have some limitations those are overcome by fuzzy logic algorithm [6]. Thus proposed system gives an idea for detection of fire by using three feature of fire like color, motion and shape and these features are powered with fuzzy logic for providing more accuracy. The main purpose of this proposed system is to decrease the false positivism for detection of fire and to increase the efficiency of the model of fire detection for indoor and outdoor scenes.

The reminder of this paper is section II provides related work studied till now on topic. Section III expresses the proposed work undertakings tended to by this paper. Section V show results and discussions and section VI present conclusions and presents future work organized as follows.

II. RELATED WORK

Real-time fire detectors [2] have been developed which combines foreground information and color information. Foreground objects are detected by removing background. For segmentation of object into fire and non-fire regions, set of sample images have been used. Fire blobs are detected using predefined rule. These rules are used to determine color information of fire. After that output is analyzed in consecutive frames by combining information of detected foreground object and color information. This real time detector processes 176x144 size frame with 30 fps. System requires less cost and less memory because it stores value of x pixel at time t and t+1. But main limitation of system is when it recognize red color object it makes alarm as fire just because output is based on only color information.

Foreground image accumulation and optical flow a technique [3] has been used for real-time smoke and flame detection. Wrong fire detection can be caused, might be because of object having reddish color, burning fire, solar reflections, and artificial light. So to overcome on this limitation physical movement is used between smoke and smoke color and flame and flame color. Physical movement is calculated firstly by foreground image segmentation using frame differential method after that flame and smoke color model are created using HIS color model. After that flame motion feature recognition is done using block image processing technique and for determining smoke region, block image processing and optical flow technique are used. It not ever gives alarm for fire like objects like car lights or tunnel accident.

Suggest an algorithm based on DFBIR (Discrete Fractal Bwounian Random Field) model [4] for fire images detection and identification. This algorithm works in three phases. Firstly, fire color model is used to detect suspicious fire region. Secondly, whether the region of suspicious fire extends continuously or not is determine by differential model. If continuously region extends then there may be fire exist. Thirdly, DFBIR algorithm used to eliminate mendacious fire. Accuracy of system is more when DFBIR algorithm is used with flame color model and differential model. But it requires more time.

Three sub algorithms to detect fire: detection of moving pixels, color detection of moving pixels and blob analysis. MoG (Mixture of Gaussians) [5] is parameter method used for detecting moving pixels. Once parameter maintenance is done foreground/background detection is made. By using predefined rule color model is developed and this model is used to analyze detected object. For detecting the foreground of video sequences, RGB color space is used to perform the proposed color detection algorithm. This algorithm eliminates non fire objects. In the last change maps and blobs are computed. False positive rate is negligible because these algorithms does not detect wrong object as fire but false negative rate is more because sometime due to clouds these algorithm fails to detect fire if actual fire take place.

To identify a boundary between thermo chemically affected area and other than thermo chemically affected area, edges of fire and flame determination is a process [6]. Due to existence of heuristic features, false alarm is generated because of use of only color information and temporal variation of pixel. Thus, to overcome these limitations, this paper presented fire detection algorithm to verify real fire pixel, by adopting a model of adaptive background subtraction with Bayesian inference.

Without having all the information about event, Fuzzy Logic System (FLS) [7] is capable for making real time decisions. For detection of fire in forest, a fuzzy logic system is used for making intelligent decision in wireless sensor networks. Instead of logical variable, fuzzy logic uses linguistic variables in natural way as a result it is mainly suitable for uncertainty applications. Thus Fuzzy Logic System is used for detecting fire as fire is not certain. Here, five membership functions as temperature, smoke, light, humidity and distance are used to build Fuzzy Logic System. In this paper, the probabilities final result of fire based on the fuzzy rules using the status of the membership functions are conferred.

For fire determination, two models of color have been developed [8] one based on luminance and second one is on chrominance. In case of luminance model, to make the classification more accurate in effectively discriminating fire and fire like colored objects and to remove existing heuristic rules, Fuzzy Logic is used. Further by statistically deriving chrominance model, discrimination between fire and non fire pixels are achieved. The result fire pixel classification can be done by merging the mask obtained from fuzzy logic enhanced luminance model in addition with the chrominance model. The model successfully brings about 99.00% correct fire detection rate with a 9.50% false alarm rate.

Multi sensor based fire detection systems [9] are important in case of automatic fire detection technology. But limitation of such technique is that it requires high time to respond. An MSBFD algorithm with temperature and smoke density like fire parameters has been introduced. Temperature and smoke sensors were selected instead of ionization system. Problem of putting ionized system have been increased due to regulation of imposed environment.

III. PROBLEM DEFINITION

Existing system mainly concentrated on detecting fire using fire features like color, motion, shape and fuzzy logic algorithm is used for producing final output to prevent from wrong alarm signals. For color feature is used as it gives good result for video images, temporal difference technique is used between two consequent frames for determining motion and for shape verification morphology method of fire is used. Finally, to calculate final score of these features fuzzy logic is used.

IV. PROPOSED SYSTEM

A. System Overview

This section reveals all the technique and methods which are being deployed for the detection of fire from the live video. Below mention steps represents the fire detection technique that our system incorporate as shown in the figure 1

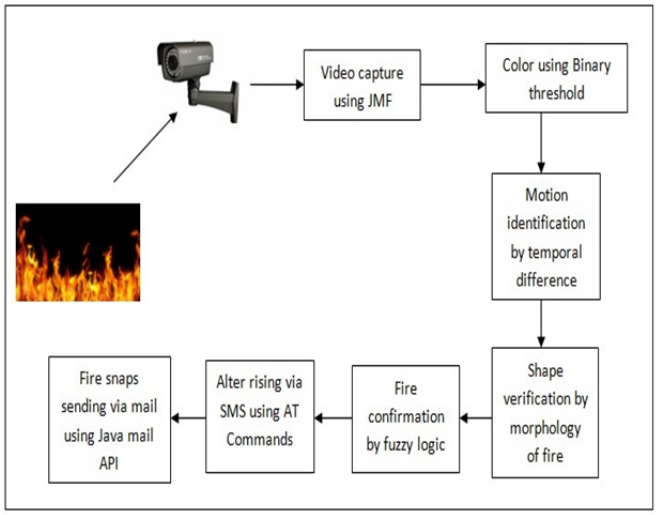

Fig.1. System overview

Step 1: This is the step of configuring the hardware webcam with our program. This process is successfully carried out by using a third party API called JMF(Java Media Files),which eventually helps to grab the live videos from the internal or external webcam attached to the system.

Then by using frame grabbing technique relative frame from the video is been captured continuously in JPEG format for the set time in seconds. Finally these frames are then used to identify the fire with the below mention steps:

Step 2: The successfully captured frame from the prior step is being used to identify the fire using color as its primary components. For this process our system uses a heuristic approach of converting the image into gray scale by using mean value of the RGB color components of the pixel. In the very next step this mean value of RGB is been verified for the threshold value of the brightness that eventually indicates the fire color (The threshold value is generally set more than 180).

Whichever the pixels are crossed these threshold are tagged as fire pixel and then finally the count is been taken for these fire pixels. If the fire pixel count is greater than the threshold count set by our system based on the size of the image, then the image frame is labeled as fire containing frame. This step is been depicted by the below mentioned algorithm 1.

ALGORITHM 1: Gray scale Conversion and Binary threshold for Fire detection using color component

// Input: Video Frame **F**
// Output: Fire detected image
Step 0: Start
Step 1: Get Image path.
Step 2: Get Height and width of the Image **F** (L*W).
Step 3: FOR **i**=0 to width.
Step 4: FOR **j**=0 to Height.
Step 5: Get a Pixel at (i, j) as signed integer.
Step 6: Convert pixel integer value to Hexadecimal to get R, G, and B.
Step 7: **AVG**=(R+G+B) /3
Step 8: **IFAVG>T**
Step 9: Pixel at (i,j) is FIRE
Step 10: **ELSE**
Step 11: Pixel at (i, j) is NOT FIRE
Step 9: End of inner for
Step 10: End of outer for
Step 11: Stop

Step 3: This is the step where our proposed system identifies the shape of the fire by using co axial variance technique, Where our system keeps checking the ratio of the fire pixels which is been identified by the past step. The ratio is identified using the following two equations (1) and (2) for every pixel. And the stream of this ratio eventually indicates the shape vector or the morphology vector of the fire.

$$M(x) = \sum_{i=1}^{N} P(i,j)/WIDTH \quad \text{_____(1)}$$

$$M(y) = \sum_{i=1}^{N} P(i,j)/HEIGHT \quad \text{_____(2)}$$

Where,
M(x) – Morphology vector related to X axis.
M(y) – Morphology vector related to Y axis.
P(i,j) – Pixel at position i and j
N – Number of pixels in the image

Step 4: Here in this step for every given time T, grabbed frame is been assigned to the past frame for the motion detection of the fire. In this process for every time the difference between the current and the past frame is been calculated for the fire pixels which was identified through the color parameter in the prior steps. If the difference is crossed the threshold value then the frame is been labeled for the fire image. This process can be depicted in the figure 2.

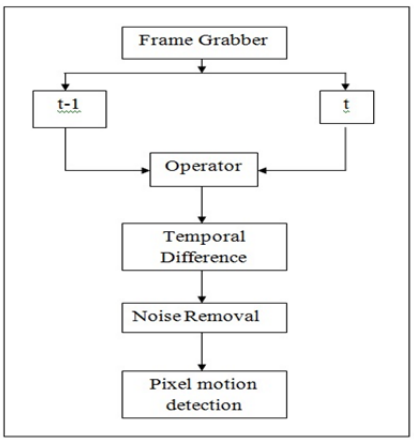

Fig 2: Overview of Fire detection by motion

The algorithm 2 clearly indicates the details of this step as follows

ALGORITHM 2: Fire Detection by motion

// Input: Time **T**, Frame $\mathbf{F_c}$, Frame $\mathbf{F_p}$, Threshold Fire pixels $\mathbf{T_h}$.
// Output: Fire Detection through motion
Step 0: **Start**
Step 1: **WHILE** (TRUE)
Step 2: for each time **T**
Step 3: $F_p \rightarrow F_c$
Step 4: calculate pixel positions of $\mathbf{F_p}$ in an vector $\mathbf{V_p}$
Step 5: calculate Pixel positions of $\mathbf{F_c}$ in an vector $\mathbf{V_c}$
Step 6: IF ABSOLUTE DIFF ($\mathbf{V_p} - V_c$) > $\mathbf{T_h}$
Step 7: Label Frame for Fire
Step 8: **END IF**
Step 9: **END WHILE**
Step 10: Stop

Step 5: This is the last step of our system where false positivism can be reduce by using fuzzy logic. This process receives the all the three parameters from the past three steps. That are fire detection by color, motion and shape, the received parameters are been tagged between the value 0 and 1.
So by using the Fuzzy crisp values, which are divided in between the ranges as follows

- ✓ VERY LOW – 0 TO 0.2
- ✓ LOW -- 0.21 TO 0.4
- ✓ MEDIUM -- 0.41 TO 0.6
- ✓ HIGH _ 0.61 TO 0.8
- ✓ VERY HIGH --0.81 TO 1.0

So any frame whose mean parameter values falls in between the HIGH and VERY HIGH is considered as the fire frame and then the relevant alarm will be raised by the system. The parameters which are come under the range VERY LOW, LOW and MEDIUM will represent the false fire detected frames.

B. Mathematical Model

1. S= { } be as system for fire detection
2. Identify Input as V= $\{V_1, V2 \ldots V_n\}$

   Where V_n= Frame numbers
3. Identify F as Output i.e. Fire detection

   S= $\{V_n, F\}$
4. Identify Process P

   S= $\{V_n, F, P\}$

   P= $\{V_f, C_i\ M_i\ S_i\ F_l\}$

Where V_f = Video frame
C_i =Color identification
M_i =Morphology identification
S_i = Shape identification
F_l = Fuzzy logic

5. S = $\{ V_n, F, V_f, C_i\ M_i\ S_i\ F_l \}$

The union of all subset of S Gives the final proposed system.

V. RESULTS AND DISCUSSION

The proposed system is built on java based windows machine with Netbeans as IDE. To evaluate the authenticity of the system the proposed technique is subjected many test as stated below.

The system is evaluated using the fire images from the publicly available datasets from URL:http://mivia.unisa.it/datasets/video-analysis-datasets/fire-detection-dataset/.
Different types of the images are been set to identify the fire by our system as shown below.

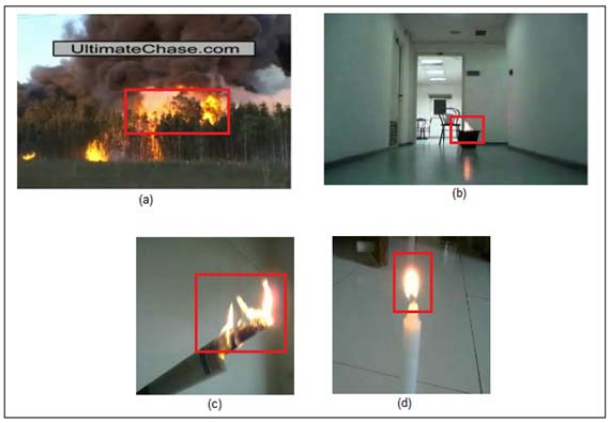

Fig 3: (a) and (b) images shown detection of fire and they are taken from the datasets. (c) and (d) images showing the detection of fire which are collected form the live streaming the videos from our camera.

Every time when fire is been detected by our system is set to be evaluate by the user for its authenticity. MRR (Mean reciprocal ratio) is one of the best evaluation method by the human for the perfection of the system.

In MRR a rank is been assigned to the output image which is ranges from 1 to 6 based on the perfection of the fire detection in the given images. If a rank 1 is given for the fire detected image then it indicates its rank as 1, for 2 it indicates rank as ½, then 1/3, ¼ ,1/5 and then finally 0.

So Finally the mean rank will be identified for the set of images using MRR equation as indicated by equation 3 and 4.

$$S = \sum_{i=1}^{n} 1\ /(\ Ranki\ ) \quad \text{_____(3)}$$

$$MRR = S/N \quad \text{_____(4)}$$

Where , n – Number of sample images
MRR is calculated for different types of image for the set of 25 numbers, Then got output for MRR is been recorded in the below table *1.*

Sr. No	Fire Image Types	MRR
1	Office	0.77
2	Forest	0.89
3	Building	0.78
4	Corridor	0.84
	MEAN	0.82

TABLE 1 : Recorded MRR

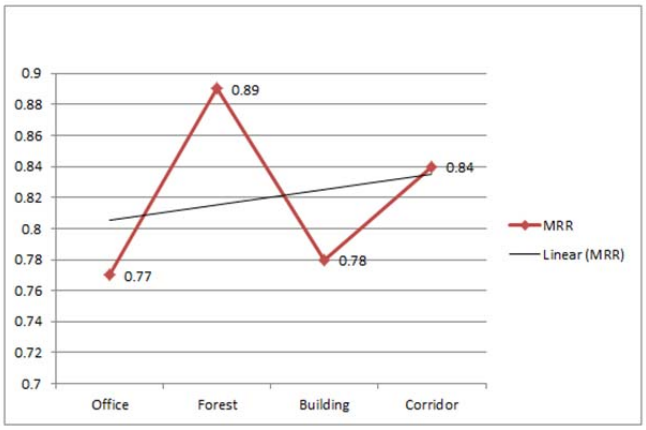

Fig 4: MRR Comparison for different types of images.

The Above plot in the figure 4 indicates that our proposed system for fire detection yields an average MRR of 0.82, which we can defend for the one of the best fire detection system using the video surveillance method.

VI. CONCLUSION AND FUTURE WORK

In the system by collecting the information related to grey scale, color, shape and motion of fire, the presence of fire is detected by supervising the surveillance camera. Proposed systems main elements are: fire color detection, motion identification, shape verification and fuzzy logic approach.

The proposed system fire detection is based on a solution of various methods using surveillance cameras. It gives us efficiency to adjust the system by applying distinct sequence of video image processing based fire detection methods and resolving the system according to different area requirement. It also provides us the best possible method for accurately detecting the flame and fire in terms of decreased false fire detection rate and hence increasing the accuracy of the system. We can develop system on multiple cameras with enhanced fire detection process using recursive multi-threading in district system.

REFERENCES

1] Pasquale Foggia, Alessia Saggese and Mario Vento , "Real-time Fire Detection for Video Surveillance Applications using a Combination of Experts based on Color, Shape and Motion", 1051-8215 (c) 2015 IEEE.

[2] Celik, T., Demirel, H., Ozkaramanli, H., Uyguroglu, M., "Fire Detection in Video Sequences Using Statistical Color Model", Proc. Internat. Conf. on Acoustics, Speech, and Signal Processing, vol. 2,no.pp. II-213 - II-216, May 2006.

[3] C. Yu, Z. Mei, and X. Zhang, "A real-time video fire, flame and smoke detection algorithm," Procedia Engineering, vol. 62, no. 0, pp. 891 - 898, 2013, 9th Asia-Oceania Symposium on Fire Science and Technology.

[4] Chen Jun, Du Yang, Wang Dong ,"An Early Fire Image Detection and Identification Algorithm Based on DFBIR Model", 978-0-7695-3507-4/08 $25.00 2008 IEEE DOI 10.1109/CSIE.2009.793.

[5] H.-Y. J. Yoon-Ho Kim, Alla Kim, "RGB color model based the fire detection algorithm in video sequences on wireless sensor network," International Journal of Distributed Sensor Networks, Volume 2014, Published 9 April 2014.

[6] Shaik Raasool ,Dr. P. Pandharinath, "An auto adaptive edge detection algorithm for flame and fire image processing", International Journal of Computer Organization Trends -Volume 3 Issue 11 - Dec 201.

[7] Pouya Bolourchi and Sener Uysal, "Forest Fire Detection in Wireless Sensor Network Using Fuzzy Logic ", 978-0-7695-5042-8/13 $26.00 2013 IEEE DOI 10.1109/CICSYN.2013.32.

[8] T. Celik, H. Ozkaramanli, and H. Demirel, "Fire pixel classification using fuzzy logic and statistical color model," in ICASSP, vol. 1, April 2007, pp. I-1205-I-1208.

[9] H.C. Muller and A.Fisc1ier,-Security technology "A Robust Fire Detection Algorithm for Temperature and Optical Smoke Density using Fuzzy Logic", ieeexplore.ieee.org, 1995.

[10] Kim, Yoon-Ho, Alla Kim, and Hwa-Young Jeong. "Rgb color model based the fire detection algorithm in video sequences on wireless sensor network." *International Journal of Distributed Sensor Networks* 2014 (2014).

[11] Celik, Turgay, and Hasan Demirel. "Fire detection in video sequences using a generic color model." *Fire Safety Journal* 44.2 (2009): 147-158.

[12] Phillips Iii, Walter, Mubarak Shah, and Niels da Vitoria Lobo. "Flame recognition in video." *Pattern recognition letters* 23.1 (2002): 319-327.

[13] Rahman, Ashfaqur, and Manzur Murshed. "Detection of multiple dynamic textures using feature space mapping." *Circuits and Systems for Video Technology, IEEE Transactions on* 19.5 (2009): 766-771.