Real-Time Fire Detection using Combination of three Fire Parameters: Color, Motion and Shape in Conjunction with the use of Fuzzy Logic

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Abstract: - *Many systems are existed for fire detection. Most of them are having performance issues and some systems require high cost for installation & maintenance. So we proposed the method in this paper is fire detection using video surveillance camera and fuzzy logic concept. There are so many methodologies available in the market for this project. The major drawback for previous system is that system does not works upon traditional logic so the ratio of failure is maximum. To decrease the failure ratio we define some novel idea. We are detecting fire by using video surveillance camera with fuzzy logic because it works on floating points also so the failure ratio can be reduced to a great extent.*

Keywords: *Fire detection, Fuzzy logic, Color model.*

I. INTRODUCTION:

Due to increasing in the number of occurrences of fire in indoor and outdoor. Sometimes it happens whenever fire is occurred, it increases rapidly in indoor and outdoor. It is very dangerous to control the fire in such condition and this may results in huge losses of life and infrastructures. So we are preparing a method for fire detection using video surveillance and fuzzy logic with the features of fire color, shape and motion.

In this system we are capturing the video by using surveillance camera and making the frame or snapshots according to set interval of time so that we can easily do operation on that frame. Each frame is send to the fire features where we do the operation on each frame using color model and shape. If the images behaves like fire then we send it for fuzzy logic operation.

There are two types of logic in the programing language. One is traditional and another is fuzzy logic. The traditional logic works only on the number 0 & 1 or true and false, so false ratio is maximum. That's why we are using here fuzzy logic. It works upon number between 0 & 1, so the false ratio gets minimized. After processing the video on the basis of color, shape and motion, it is sent for the fuzzy logic processing. Fuzzy logic system is the system which is able to take real time decision according to the acquired input. Fuzzy logic is mainly used in the intelligent system so that it can take its own action. It is used in almost all camera/image processing technique. Fuzzy logic algorithm is developed using five membership function. It is very suitable for those application which are uncertainties in nature. After performing various operations under fuzzy logic, it is decided that whether this is occurrence of fire or not.

In this paper section II is dedicated to literature survey, where section III is describes the various proposed techniques in details. Section IV evaluates performance of the system and section V concludes the paper with the some possible future extensions.

II. RELATED WORKS

Pietro Morerio, Lucio Marcenaro and Carlo S. Regazzoni. [1] Proposed a system to detect the fire using the surveillance camera but methodology of this paper is depending upon the sensors. As we described we are trying to minimize the cost but if we use the sensors then the installation and maintenance cost is high. If we want to cover large area then more number of sensors are required. This results in the cost of this type of system is high and the efficiency of this method is very less.

Pouya Bolourchi and Sener Uysal. [2] The multi-purpose integrated homeland surveillance security systems are usually located in remote areas. Intelligent decision making (IDM) capability emerges as the primary feature in the realization of the T/R architecture. The aim of employing IDM is two-fold. First is to save energy, as the system operation is desired to be autonomous based on the available solar power and the corresponding battery-bank. Second is to activate the necessary action(s) required based on the pre-defined sensitivity levels. The current work is focused on the second aim using the pre-defined sensitivity levels. We propose to use a wireless sensor network (WSN) for data harvesting to be used as raw input data into our control system. Fire detection has been

chosen to illustrate the IDM capability of the system. A Fuzzy Logic algorithm is developed using five membership functions as temperature, smoke, light, humidity and distance. Simulation results for the probability of fire based on the fuzzy rules using the status of the membership functions are presented in the paper.

Antonio Buemi, Davide Giacalone, Filippo Naccari and Giuseppe Spampinato . [3] This paper presents Horus, a novel algorithm for fire detection in videos. It exploits a fuzzy model to discern the frame's fire areas by color recognition. The classic Mamdani fuzzy inference process allows estimating the membership degree of each pixel to the set of fire colored pixels. The final check analyzes the motion dynamic of the areas classified as fire to reduce the risk of false positives.

Robert A. Sowah, Abdul R. ofoli and Selase N. Krakani. [4] This paper presents the design and development of a fuzzy logic based multisensor fire detection system and a web-based notification system. Until recently, most consumer grade fire detection systems relied solely on smoke detectors. The protection provided by these has been established to be limited by the type of fire present and the detection technology at use. The problem is further compounded by the lack of adequate alert and notification mechanisms. A typical system relies on the physical presence of a human being to act on the alert. In developing countries, poor planning and addressing negatively affects the fire and rescue crew's response time. To address this problem, a fuzzy logic system was implemented using an Arduino development board with inputs from an MQ2 smoke sensor, a TMP102 temperature sensor, and a DFRobot flame sensor. The output of the detection system is sent over short message service (SMS) using a SIM900 global system for mobile communication (GSM) module to the web-based system and the house owner or caretaker in real-time. With access granted to the web-based system, the fire and rescue crew also get notified in real-time with location information. A comparison between the efficiency of the notification system employed by standard fire detectors and the multisensor remote-based notification approach adopted in this paper showed significant improvements in the form of timely detection, alerting, and response.

Robert Sowah, Kwame O. Ampadu, Abdul Ofoli, Koudjo Koumadi, Godfrey A. Mills, and Joseph Nortey. [5] The immense benefits of fire in road transport cannot be overemphasized. However more than two thousand vehicles are damaged by unwanted fire on a daily basis. On a global scale, incendiary losses to the automobile and insurance industries have ran into billions of dollars over the last decade. A not-so-distant contributory factor is the lack of a sophisticated fire safety system on the automobile. This has been addressed by designing and implementing fuzzy logic control system with feedback over an Arduino micro-controller system. The automatic system consisting of flame sensors, temperature sensors, smoke sensors and a re-engineered mobile carbon dioxide air-conditioning unit was tested on a medium sized physical car. Results show that the automobile fire detection and control system devoid of false alarms, detects and extinguishes fire under 20 seconds. An innovative, very promising solution module for hardware implementation in fire detection and control for automobiles has been developed by using new algorithms and fuzzy logic.

III. PROPOSED SYSTEM

This area uncovers all the procedure and techniques which are being conveyed for the identification of flame from the live video. Beneath specify steps speaks to the fire identification method that our framework fuse as appeared in the figure 1.

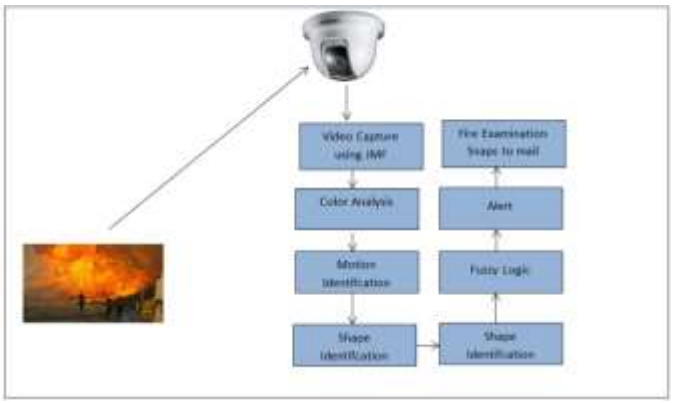

Figure. 1: System Overview

Step 1: This is the progression of arranging the equipment webcam with our program. This procedure is effectively completed by utilizing an outsider Programming interface called JMF(Java Media Records),which in the end gets the live recordings from the inside or outer webcam appended to the framework.

At that point by utilizing outline snatching system relative edge from the video is been caught consistently in JPEG organize for the set time in seconds. At long last these casings are then used to distinguish the fire with the underneath say steps:

Step 2: The effectively caught outline from the earlier stride is being utilized to recognize the fire utilizing shading as its essential parts. For this procedure our framework utilizes a heuristic approach of changing over

the picture into dark scale by utilizing mean estimation of the RGB shading parts of the pixel. In the exact next stride this mean estimation of RGB is been confirmed for the edge estimation of the brilliance that in the end demonstrates the fire shading (The limit esteem is by and large set more than 180)

Whichever the pixels are crossed these edge are labeled as flame pixel and after that at last the number is been taken for these fire pixels. On the off chance that the fire pixel check is more noteworthy than the edge number set by our framework in view of the measure of the picture, then the picture casing is named as flame containing outline. This progression is been delineated by the beneath said calculation 1.

ALGORITHM 1: Fire detection Algorithm for color component

// Input: Video Frame **G**

// Output: Fire detected image

Step 0: Start

Step 1: Image path.

Step 2: Height and width of Image **G** (L*W).

Step 3: FOR **i**=0 to W.

Step 4: FOR **j**=0 to H.

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: **IF AVG** >**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 progression where our proposed framework recognizes the state of the fire by utilizing co pivotal difference procedure, Where our framework continues checking the proportion of the fire pixels which is been distinguished by the past stride. The proportion is recognized utilizing the accompanying two conditions (1) and (2) for each pixel. What's more, the surge of this proportion inevitably demonstrates the shape vector or the morphology vector of the fire.

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

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

Where N(x) – Morphology vector related to X axis.

N(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 progression for each given time T, got edge is been doled out to the past edge for the movement discovery of the fire. In this procedure for each time the distinction between the current and the past edge is been figured for the fire pixels which was recognized through the shading parameter in the earlier strides. On the off chance that the distinction is crossed the limit esteem then the casing is been marked for the fire picture. This procedure can be portrayed in the figure 2

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

Algorithm 2: motion Detection in Fire

// 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 a vector $\mathbf{V_p}$

Step 5: calculate Pixel positions of $\mathbf{F_c}$ in a 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 stride of our framework where false positivisms can be decrease by utilizing fluffy rationale. This procedure gets the all the three parameters from the previous three stages. That are fire discovery by shading, movement and shape, the got parameters are been labeled between the esteem 0 and 1.

So by utilizing the Fluffy fresh values, which are partitioned in the middle of the extents as takes after

- ✓ VERY LOW (VL) – 0 TO 0.2
- ✓ LOW (L) -- 0.21 TO 0.4
- ✓ MEDIUM(M) -- 0.41 TO 0.6
- ✓ HIGH (H) _ 0.61 TO 0.8
- ✓ VERY HIGH(VH) --0.81 TO 1.0

So any casing whose mean parameter values falls in the middle of the HIGH and HIGH is considered as the fire edge and after that the significant caution will be raised by the framework. The parameters which are gone under the range LOW, LOW and MEDIUM will speak to the false fire distinguished casings.

IV. RESULTS AND DISCUSSIONS

So any casing whose mean parameter values falls in the middle of the HIGH and HIGH is considered as the fire edge and after that the significant caution will be raised by the framework. The parameters which are gone under the range LOW, LOW and MEDIUM will speak to the false fire distinguished casings.

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.

Figure 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.

Each time when fire is been recognized by our framework is set to be assess by the client for its legitimacy. MRR (Mean corresponding proportion) is one of the best assessment strategy by the human for the flawlessness of the framework.

In MRR a rank is been appointed to the yield picture which is extents from 1 to 6 in view of the flawlessness of the fire location in the given pictures. On the off chance that a rank 1 is given for the fire recognized picture then it demonstrates its rank as 1, for 2 it shows rank as ½, then 1/3, ¼ ,1/5 and after that at last 0.

So At long last the mean rank will be recognized for the arrangement of pictures utilizing MRR condition as demonstrated by condition 3 and 4

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

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

Where n – Number of sample images

MRR is computed for various sorts of picture for the arrangement of 25 numbers, Then got yield for MRR is been recorded in the underneath table 1.

Trial No	Fire images Type	MRR
1	Office	0.78
2	Forest	0.80
3	Building	0.75
4	Corridor	0.84

TABLE 1: Recorded MRR

The Above plot in the figure 4 shows that our proposed framework for flame recognition yields a normal MRR of 0.82, which we can guard for the one of the best fire location framework utilizing the video observation technique.

On putting our framework for further investigation of correlation with another strategy for flame location portrayed in [6] for parameters like Exactness and Effectiveness. We discovered a few outcomes that are tabled as beneath.

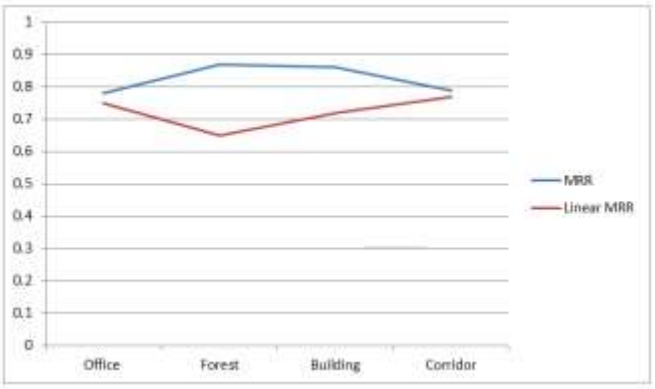

FIGURE 4: MRR COMPARISON FOR DIFFERENT TYPES OF IMAGES

Fifty Images	Multi-Expert	ROI
TP	57	55
TN	8	4
FP	2	2
FN	0	0
accuracy	91	94
efficiency	92	83

TABLE 2: Comparison Table

Where,

- True positive = correctly identified
- False positive = incorrectly identified
- True negative = correctly rejected
- False negative = incorrectly rejected

Accuracy and Efficiency can be given by

Following Equations

Accuracy = TP/ (TP+TN)*100%

Efficiency = (TN+TP/TN+TP+FN+FP)*100%.

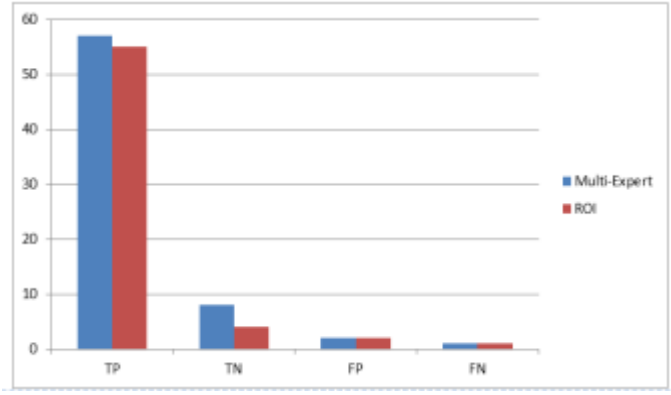

Figure 5: Comparison Graph

On plotting the graph for the parameters given in the table 2 which is represented in the figure 5. It clearly indicates that our system of multi expert system performs well compared to that of ROI method.

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