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EFFICIENT FIRE DETECTION THROUGH VIDEO SURVEILLANCE

1 Sneha Shegar 2.Reshma Afreen Akbar Shah 3. Ashwini Saswade 4. Akshata Gilbile 5. Dipali Sandbhor

Samarth Group Of Institute Engineering College Belhe, Department Of Computer Engineering

***Abstract* — Fire is one of the most destructive forces that have been known to mankind. Fire has enabled a lot of technologies in a controlled format. But the uncontrolled and destructive fire has been the cause of large-scale destruction in various parts of the world. Fire needs to be contained effectively and timely, barring which it can cause significant amount of damage in a short time. There have been many researches that have been performed for the purpose of fire detection through video input from a live source. Many of these research directions have not been up to the mark as it has not reached the desired accuracy in a stipulated amount of time. To overcome these limitations, an innovative approach has been outlined in this methodology that utilizes the fire detection through a multi expert system. The proposed system implements, fire color detection, motion detection and fire shape detection and combines them in a multi expert system. The multi expert system is combined with the Decision tree approach to improve the accuracy and reduce the false positives significantly.**

Keywords: *Fire detection, Image Morphology, Binarization, Decision Tree.*

I INTRODUCTION

Fires are highly destructive and can cause a lot of damage as they start increasing in size and consuming material all around. Combustion through fire is complete and it creates a lot of smoke and Ash. The fire has the capability of spreading fast by being assisted through wind and combustible material. Forest Fires have been responsible for creating a lot of damage to the ecological wellbeing of an area by completely devastating and destroying everything in its path. Forest fires especially dangerous has the wreak Havoc on the inhabiting species as well as lead to large-scale removal of forest cover.

Fires can also happen in residential areas and houses. These fires usually caused due to short circuits or mismanagement of the radiators or any other heating elements in the house. Fire can be highly difficult to predict and can also turn into highly dangerous phenomena that can lead to large scale loss of life and property in their wake. There is a lot of precaution that is put in place to reduce the incidence of fires in various different situations. Such as sprinklers and smoke detectors that are used to detect the signs of a fire and provide preliminary treatment of the fire so that it does not spread and gain a lot of power which can lead to very disastrous results. There are fire brigades in every major location in the City that responds to any fires so that it can be contained and prevented from spreading further.

Technological advances have also led to the creation of various different sensors that can be used for the purpose of detecting fire. But most of the sensors are not as accurate and should be used in a combination with each other to provide a somewhat accurate picture of a fire. The use of video surveillance can also help in the early detection of fire which can help in reducing the damage done by such fires. Image processing is a highly specialized concept that processes the image and content to provide insightful information automatically. This is done through the use of video footage that is converted into frames and fed to an image processing algorithm. The image processing algorithm processes the image to the use of machine learning and provides information about the condition of Fire if it exists or not. This technique is highly superior as there are already various cameras in place due to the security concerns that have been rising in the world.

In the past few years, there has been a large-scale improvement in the quality of life as well as a significant development in the social economy. This has led to an increasing number of people highly concerned about various aspects of safety and security.

This research paper dedicates section 2 for analysis of past work as literature survey, section 3 deeply elaborates the 2 proposed technique and whereas section 4 evaluates the performance of the system and finally section 5 concludes the paper with traces of future enhancement.

II RELATED WORKS

D. Pritam introduces the fire detection systems that have been getting increased attention from various researchers nowadays. This is due to the fact that fires have been highly damaging and have led to large scale destruction on various events. Traditionally fire is detected using an array of different sensors such as heat temperature smoke etc. Some of these devices are highly expensive and have to be used in combination with other sensors to achieve high accuracy. Therefore, the use of video surveillance or vision-based fire detection techniques has been extensively useful and increased accuracy [1]. Therefore, the authors in this paper proposed an efficient and accurate fire detection technique that utilizes image processing in the LUV color space to provide effective fire detection. The proposed methodology has been tested to achieve higher accuracy than the other techniques on the same platform.

S. Wu elaborates on the problems that are faced by wild detecting fire in a forest. The forest is a rapidly changing landscape where a lot of dense shrubbery trees and animals have got a lot of movement. This movement is highly difficult to predict and model into a fire detection system. Therefore, the authors in this paper discuss effective object detection techniques that can help detect forest fire in real-time [2]. The real-time protection of forest fire would allow for effective and timely remedial measures to be taken to reduce the damage done by the Fire. The proposed technique has been tested extensively to yield promising results.

S. Lei narrates that fire detection has been highly difficult and largely uncharted territory for various researchers working on image processing. Most of the conventional techniques that utilize image processing for fire detection have very little robustness and very low adaptability to interference [3]. Therefore, the authors in this Publication have proposed and improved fire detection technique that is based on
utilizing consecutive frames and their centroid variety to effectively classify fire. The probable methodology utilizes the RGB-HIS color model for the purpose of identification of the flame. The proposed methodology is highly accurate and
detects fire correctly.

H. Dang-Ngoc introduces the paradigm of utilizing unmanned aerial vehicles for fire detection through the use of aerial footage. Fires are highly dangerous and destructive and can be fatal to a lot of forest fire officials that get inside to have a closer look. Therefore, the use of unmanned aerial
vehicles is useful for forest fire surveillance. For this purpose, the authors in this paper have designed a system for analyzing aerial video footage to detect fire in the forest [4]. The proposed methodology has been tested extensively and the experimental results indicate that the accuracy of the model is 93%.

S. Vijayalaxmi states that most of the fire detection systems that are utilized are not highly accurate and often result in fake fire detection. Most of this is due to the fact that the various sensors can sometimes provide garbage values that cannot be trusted [5]. The authors in this paper outline an efficient fire alarm system that utilizes video frames as input for the detection of Fire. The proposed methodology utilizes Spatio-temporal features and motion information to identify fire effectively. The experimental results indicate that the fire alarm is highly accurate and a much better system than and the conventional sensor system.

D. Zhang explains that real-time fire detection has been a challenge for various reasons such as the reaction time of various sensors and algorithms that are used to combine the data and process it. Therefore, the use of video sequence data is very useful for the detection of fire effectively [6]. Thus, in this Publication, the authors have utilized contour shaping information along with pixel value variation in fire video sequences for detection of fire in real-time. Daughters of employed hidden Markov models for eliminating the false positives in the fire detection system. The experimental results indicate that the proposed methodology produces promising results in the fire detection paradigm.

Surveillance video analysis has been extensively studied. However, compared to the vast amount of research in broadcast video search [7,8], very few systems address the search in surveillance video. Lee and Smeaton [9] describe a user interface to retrieve simple surveillance events like presence of person and objects. Stringa and Regazzoni [10] proposed a content-based retrieval system for abandoned objects detected by a subway station surveillance systems. In their system, similar abandoned objects can be retrieved using feature vectors of position, shape, compactness, etc. Berriss et.al. [11] utilized the MPEG-7 dominant color descriptor to establish an efficient retrieval mechanism to search the same person from surveillance systems deployed in retail stores.

Meesen et.al. [12] analyzed the instantaneous object properties in surveillance video key-frames, and performed content-based retrieval using a generic dissimilarity measure which incorporates both global and local dissimilarities between the query and target video key-frames. There is significant effort in industrial surveillance systems targeted toward real-time event detection. Very few of these systems have focused on video search. 3VR does provide capabilities to search for a person based on face recognition. In summary, there is a very limited number of both research and commercial systems focused on searching surveillance video. As a surveillance systems grow in scale and utility, there is an increasingly critical need to provide the Corollary search capabilities.

// Input: Frame Image F_{IMG}

// Output: Fire Color Detected Image F_C

Function: getBInaryFire(F_{IMG})
1: Start
2: Set T [Threshold]
3: ***for*** i = 0 to size of Width of F_{IMG}
4: ***for*** j=0 to size of Height of F_{IMG}
5: $P_{SIGN} = F_{IMG\,(ij)}$ RGB
6: R= P_{SIGN} >> 16 & H_D
7: G= P_{SIGN} >> 8 & H_D
8: B= P_{SIGN} >> 0 & H_D
9 : ***if*** ((R+G+ B)/3 > T) , ***then***
10: $F_{C[i,j]}$ = (255<<16 | 255<<8 | 255)
11: ***else***

III PROPOSED METHODOLOGY

This section outlines all the procedures and steps that are being implemented for the detection of fire and intrusion a live video feed capture. Procedure mentioned below illustrates the fire detection approach that incorporated in the presented system as depicted

Step 1: Frame Capuring - This is the initial stage that details the configuration of the hardware webcam with our program. This procedure is successfully implemented throught the utilization of a third party API called Open CV, which assists in grabbing the live videos from the internal or external webcam connectd to the system.

Then through the utilization of the frame grabbing approach the concerned frames from the video is extracted subsequently according to the set time given in seconds in the JPEG format. Finally, the extracted frames are then utilized to detect the fire with the procedure mentioned below:

Step 2: Gray scale and Binary Conversion - The frames captured in the prior step are utilized to detect fire where the primary components used is its color. The mean value of the RGB color components of the pixel are utilized for realizing a heuristic approach and converting the image into a gray scale image. The threshold value which is usually set at 180, is then used to verify the mean value of RGB which indicates the color of the fire.

The numbers of pixels that are conforming to the threshold are counted. The count is then stored as the fire pixel count. This count is then further analyzed for the threshold count for the number of decided by the system. If the count exceeds this threshold then the frame is said to contain fire based on the color and is labeled subsequently. This step is illustrated by the algorithm mentioned below.

ALGORITHM 1: Gray scale Conversion and Binary threshold for Fire detection using color component
12: $F_{C[i,j]}$ = (0<<16 | 0<<8 | 0)
13: ***end else***
14: ***end for***
15: ***end for***
16: **return** F_C
17: **Stop**

Step 3: Co-Axial Ratio -This step of the procedure is utilized for the identification of the shape of the fire in the presented technique. This is achieved through the utilization of the Co-axial variance approach. In this approach the ratio of the fire pixels obtained in the previous step is utilized for the calculation of the equations 1 and 2 given below. This is repeated for every pixel that is extracted in the previous step. The ratio stream obtained through these equations and the ratio represents the morphology vector or the shape vector of the fire.

( ) = ∑ (,)/ =1 ______________ (1)

( ) = ∑ (,)/ =1 ________________ (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: Fire Motion Estimation - This is the penultimate step that is involved in the fire detection that is utilized for the detection of the motion of the fire. For every time interval T the frame grabbed is compared to the previous frame for a reference in the motion. The fire pixels values obtained in the previous steps are segregated into previous and current frames whose difference is then calculated. This is done through the utilization of color parameters that are obtained. The parameters are subjected to the threshold calculation, if the obtained values are above the threshold then that frame is labelled as the fire frame. This process is detailed

Step 5: Fire Detection through Decision Tree - In this step of the procedure the false positives are eliminated through the utilization of the Decision Tree. The parameters obtained in the previous steps are given as an input to the Crisp Value Generator module. The parameters are shape, motion and color of the fire. These values are tagged in a Crisp value manner where the values range from 0 to 1.

The crisp values that are obtained in the previous step of this procedure are segmented according to the ranges given below

✓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

The segregation allows for the effective division of the values as the VERY LOW, LOW and MEDIUM values are highly uncertain and are false, therefore are discarded. The parameter values representing the HIGH and VERY HIGH are values that are considered as very likely to be an indication of fire and are subsequently used to raise the alarm.

IV RESULT AND DISCUSSIONS

The presented technique is designed on the NetBeans IDE using the java programming language on a laptop based on the windows operating system. The laptop consisted of a standard hardware such as Intel Core i5 as the processing unit along with 4GB of RAM and 500 GB of storage. For the assessment of the accuracy of the methodology the presented approach is subjected to a plethora of tests as given below.

The system is experimented using the images of fire from the datasets that are publicly available from URL: *http://mivia.unisa.it/datasets/video-analysis-datasets/fire detection-dataset/* . The dataset contains various types of fire

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images that are fed to our system for its evaluation and fore detection as given in the figure 3 below.

The RMSE or the Root Mean Square Error is implemented for the thorough evaluation of the error in the fire detection through live video feed. For the goal of realizing the error rate, two parameters for evaluation purpose are extracted. The expected fire detection and the achieved fire detection are the two correlated and continuous parameters that are used for error evaluation purpose.

Equation given below is utilized to measure the Error rate of the proposed technique.

Where,

$\sum$ - Summation
$(x_1 - x_2)^2$ - Differences Squared for the summation in between the expected fire detection and the achieved fire detection
n - Number of samples or Trails

images contain fire obtained from the datasets. (c) and (d) are the images containing fire that are captured form the videos from our camera for the fire detection purpose.

The extensive experimentation of the presented technique is attained using the RMSE methodology, and the experimental outcomes are listed displays the experimental outcomes listed in Table 7 above. The graph represents the Mean Square Error rate between the expected Fire Detection and the achieved Fire Detection for a number of trials of experimentation that are implemented for an in-depth evaluation. There are significant number of trials that are executed in each of the experiments. The values of MSE and RMSE attained through the experimental evaluations are 16.66 and 4.08 respectively. The calculated values of RMSE for the Fire Detection through the live video are well under the criteria of a first-time implementation. This illustrates the increased accuracy offered by the proposed methodology. The RMSE values attained through the experimentation strengthens the argument of increased reliability offered by the presented technique.

V CONCLUSION AND FUTURESCOPE

The presented approach for the purpose of Fire has been implemented successfully through the use of an multi expert system. The fire detection is performed through the use of live video surveillance feed as an input. The video feed is converted into frames according to the desired interval. The collected frames are processed by conversion into a gray scale image. The grayscale image is utilized for the identification of the fire by collecting the parameters related to the fire, such as color, shape ,motion and edges. The multi expert system utilizes these parameters to compare with the pre-determined threshold values of the system. If the values exceed the threshold the system generates an alarm. The multi expert system is called as such due to the combination of highly customizable detection approaches which includes color detection, motion detection and shape detection systems. The output of the fire characteristics obtained from the system is given as an input to the Decision tree system. The Decision Tree system applies the Decision Tree value segregation to achieve effective fire detection which is devoid of any false positives. The RMSE evaluation of the proposed methodology achieves the value 4.08 which is a significant achievement for a first attempt.

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. The system cannot be implemented outdoors for the purpose of fire detection in a larger area. The presented technique can also be implemented in the form of an API for effective and Secure integration.

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