Real-Time Fire Detection for Video Surveillance Applications using Multi Experts System

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Abstract— In this proposed system the method able to detect fire by analyzing the Videos acquired by surveillance cameras is introduced. Two main novelties have been introduced first, complementary Information, respectively based on colour, shape variation and Motion analysis, are combined by a multi expert system. Second, a novel descriptor based on a bag-of-words approach has been proposed for representing motion. The previous systems were developed but the results were not much significant as they were having their own limitations. Some of them were working on colour while some on shape or motion hence they had own drawbacks. Our system will try to overcome those as we are proposing the system that will have a separate module for shape variation, a module for colour evaluation and a module for motion evaluation. The multi expert based system takes the input of all this modules and then the decisions taken by the experts are combined by a MES (multi expert system) classifier based on a weighted voting rule, which finally assigns a class to each blob. The Main advantage deriving from this approach lies in the fact that the overall performance of the system can be significantly increases with a relatively small effort.

Key words: Image Segmentation, Bag-of-Words, Fire Detection

I. INTRODUCTION

The idea about automatic fire alarm system is designed to detect the unwanted presence of fire by monitoring environmental changes related with combustion. In general, a system is either classified as automatic, manually activated, or both. The fire detection systems can be used to notify people to evacuate in the event of a fire or other emergency situation or services and to prepare the structure and associated systems to control the spread of fire and smoke. Fire detection alarm systems have become increasingly with functionally more capable and reliable in recent years. The system designed to fulfill two general purpose which are protection of property and Assets and protection of life. As many result of state and local area the life-safety aspect of fire protection had plays a major role in the last two decades. There are number of reasons for the substantial increases in the life-safety form of fire protection during last few years, most of them are: The high-rise construction and the concern for life safety within these build. A growing awareness of the life-safety in residential, institutional, and educational occupancies. Increased of making new building materials and furnishings that create large amounts of toxic products. In smoke detection and related technology made possible through quantum advances in electronic technology.

II. MOTIVATION

Generally the fire alarms are based on the sensors like smoke, heat etc. The main objective of this system is Detecting fire without smoke detector sensors. Traditional fire detectors are very costly and they are not suitable for open spaces. Hence developing a system that works on pre-existing surveillance system discards the requirement for fir sensors was the main motivation on the system. Existing fire systems highly produce false alarms and often detect fire when its too late. So it is needed to develop an efficient low cost fire detection system with less response time and Computer based techniques has a great potential all to meet these requirements.

III. LITERATURE SURVEY

In the previous studies many methods were proposed, with the objective to detect the fire form the videos obtained from the CCTV camera placed on the site were the risk of fire emergence was more The current research efforts [1][2] aimed on in increasing the correctness and performance of the system so as to exploit the system in commercial field. As we are familiar with the type of fire that occurs in major ratio that is by combustion of plastic, wood, paper and other materials, so the classification of fire properties can be distinguished based on color and motion. Hence it was considered color as a reliable way to work on its color components (RGB, YUV, or other color space) to determine the presence of flames. This basic idea inspires several methods, in [3] and [4] the background subtraction technique and RGB color model are used for identifying the fire pixel in the image. A set of fire images have been used and experimentally a region fire is detected and if the pixel matches with the particular region then it is classified as fire .the aim advantage of this method was allow computational cost which was processing nearly 30 frames per second for (176x144) resolution of image. In HIS color space the different rules were used for filtering the pixels in [5] differently from [3] and [4], which was suitable for describing the people-oriented way of color. The similar way was descried in [6] where a fire matrix was defined by combination of HSV saturation and RGB color on the assumption that the green component has a wide range of changes as that of red and blue in a fire pixel.

The common disadvantages or limitations of above stated approaches is that they are very sensitive to the increase or decrease in the brightness, which caused a large number of false positive results(fire detected even when there is no fire) due to variation in the tonalities in red and occurrence of shadow. This problem can be overcome by switching to a YUV color space. The luminance from the chrominance was effectively separated by the experimental set of rules in [7],which reduced the false positive result in the system information coming from YUV color are combined by a approach called fuzzy logic approach . In [9] the thresholding of potential pixel of fire is based on support vector machine which provides a better generalization without the knowledge of problem domain hence a

probabilistic approach on YUV is proposed. Although these above mentioned algorithms are less sensitive to the change in luminance but their main drawback lies in their high computational cost as the support vector dimensions increases The physical properties of fire like the dynamic texture of fire and the saturated flame is used to create a feature based vector on an optical flow in [10]. In order to speed up the segmentation process in [11] the dynamic texture for two phase texture process of detection has been proposed. The intensity motion orientation and wavelet energy variation was combined by using a fuzzy logic in [12] for handling the irregularities of fire. Flame boundaries was identified by applying the wavelet transform in [13] but cannot be used for still image and generally require frame rate higher than 20fps,so applicability was limited. The Bayesian classifier in [14] is used to analyses the frame-to-frame changes in color, surface, area size, boundary roughness and skewness.so variation in appearance and color helps the reliability of detection. The false positive results were decreased by the multi resolution 2-dimensional wavelet analysis that increased the thresholding on RGB color space color which evaluates the shape and energy variation in [15]. The shape variation was computed as ration between perimeter and the area of the abject in area of interest. This strategy is simple and appreciable when there is any stable or moving rigid object in the frame. Also on other side it is to be considered as shape associated with the non-rigid object such as a human being. If we consider a moving human in a frame his movements of arms and legs are found to be highly variable in consecutive frames.Hence the disordered shape of a human may be confused with the shape of disordered fire resulting in again the false positive results. So it can was concluded that for the motion base approaches of fire detection has its limitations and the performance improvement can be achieved if: first, several sensitive parameter needs to set properly. Second, the shape and motion of the fire flame depends on the burning material and the climatic condition (fire flame motion due to wind). In [16] spatio-temporal properties are introduced based on novel descriptor. The image was divided into 16 X16 squares and each square was quick filtered by simple color model of the flame pixel. Then on the blocks that were remaining a feature vectors is computed by the covariance matrix containing the ten properties associated to color and spatial and temporal intensity derivatives. After that the SVM classifier is applied to differentiate fire from non-fire block. As it does not require the background subtraction technique it can be used in a moving cameras but contradictory it produces false positive results in sterile areas, to flashing redlight. Several classifiers were combined for reliable results in [8]. Hidden morkov model (HMM) is used for color detection; uniform texture of flames is analysed by spatial wavelet; and the irregular shape of fire contour was detected by wavelet analysis. Then the decisions of this algorithm were linearly combined by set of weights which are updated with (LMS) least mean square strategy each time when a ground truth value is available. The combination function is improved by exploiting the occasional feedback of the user in the major advantages of such approach. But the drawback is that we have to choose the learning rate parameters very properly, to ensure the coverage weights are updated in a reasonable time.

IV. PROPOSED ARCHITECTURE

The architectural diagram represents the complete overview of the system. The algorithm stated in [17] detect the object in moving scene: a background updating strategy deals with the changes in environment in the day time, after that the foreground extraction is done and finaly blobs associated with each object are obtain by applying connected component labling.

A. Multi Expert Evaluation

The main characteristic of MES is combination rule as it has been proved one of the strongest classifier. The main strategy is that each supporting classifier can express its weight. Now consider the situation where the color expert and movement expert identifies a blob as fire and vote is 0.8 and 0.7. For these expressing classes the weight and vote will be0.8 and 0.7 as output correspond to 0 and 1. Hence the votes of all classifier are taken from them and MES decide that the fire is present (F) or absent (F') in the blob.

The final result of MES is obtain by maximizing the reliability of the classes.

$$\psi(i) = \frac{\sum_{k\in\{CE,SV,ME\}} \delta_{ik}(b)\cdot w_k(i)}{\sum_{k\in\{CE,SV,ME\}} w_k(i)}.$$

B. CE: Color Evaluation Expert

The properties of color are evaluated from the YUV as it is less sensitive to the changes. As specified in literature the YUV separates luminance from coherence and hence is less brightness sensitive. As proposed in [7]. This expert uses the six combination rules r1, r2….r6 which are able to model the flame color. This rules are based on the experimental evidence that flames exhibits the value of Red channel value greater than green channel, as well as green greater than blue.

$$R(x,y) > G(x,y) > B(x,y)$$

This conditions are equally represented in the YUV plane by adopting conversion rule [18]. r3,r4 are assumption that Red color component of pixel is greater than the mean Red color component of the flame. YUV space it specifies a fire pixel has Y and V component greater than Y and V values in that flame. Finally it difference between U and V components are characterized. Hence the rule.

$$r_6^c : |V(x,y) - U(x,y)| \geq \tau_c.$$

Here the Tc has been set to 40.

C. SV: The Expert Based On Shape Variation.

As the characteristic of fire flame is that it changes the shape very quickly. This expert analysis the change in the variation of blobs shape across consecutive two flames. The algorithm in [15] calculate the area At and parameter Pi of the blob and then these values are use to compute thee r1, parameter – area ratio. Which indicates shape complexity.

$$Rt = Pt/At$$

After obtaining the Rt, the variation in shape is determined by comparing the ratio of one frame to another frame. Which is next frame.

$$s_v^t = \left| \frac{r_t - r_{t-1}}{r_t} \right|$$

D. ME: Movement Evaluation Expert

The ME works on novel descriptor [19] which adopt Bag of words approach. The basic characteristic of fire flame is its

movement of flames in multiple direction. The flames move in several different direction at same time in unpredictable way. The bag of word approach has been used in various field such as audio engineering and action recognition and event detection. The idea behind this concept is occurrence classified pattern. The vectors are build for the each input and the number of occurrence increase the vector for that specific input also increases. As for applying Bag of word approach for our problem of movement Evaluation. Each direction is considered as one vector in one vector frame and the same points movement is calculated in next frame. If the movement is in all direction or is multidimensional then the characteristic of frame can be determine by the bag of word approach and if the movement of a point between two consecutive frame found to be in one direction then the expert can say that it is not fire as the characteristic property of flame has been not achieved.

V. EXPERIMENTAL RESULT

This system has been tested on the real fire situation in the different environment and the results are achieved which are around 83.53% accurate and 11.76% of false positive has been detected.

The following table describes the test result.

Test Case Name	Input	Purpose Of Test	Expected Result	Actual Result	Remark
Color Detection	Image	To detect color	Color detected	As expected	PASS
Movement Detction	Real time camera	Tp detect movement	Movement detected	As expected	PASS
Shape Detection	Image	To detect image	Image detected	As expected	PASS
Blobs Creation	Image/ real time data	To create blob	Blobs and square drawn	As expected	PASS

Table 1: Test Result

Here the images of real time detection

A. In Light

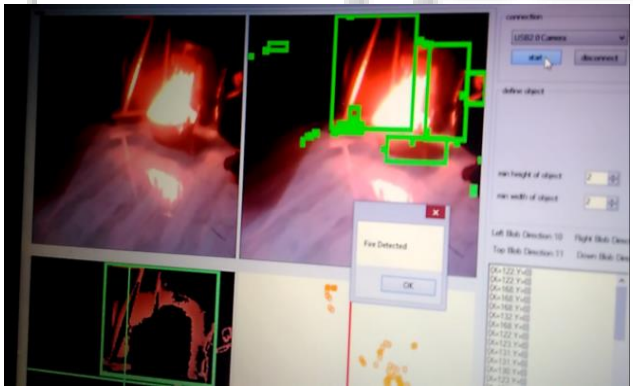

Fig. 1: In light

B. Open Environment1

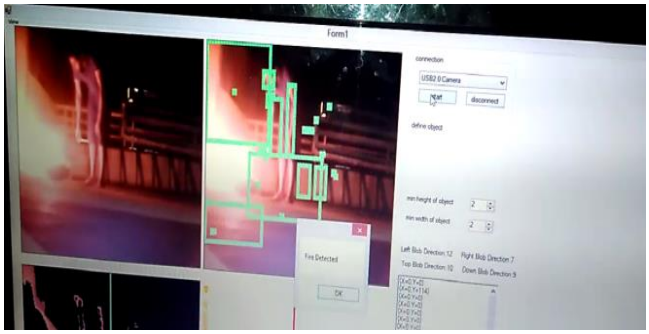

Fig. 2: Open environment1

C. Open environment 2

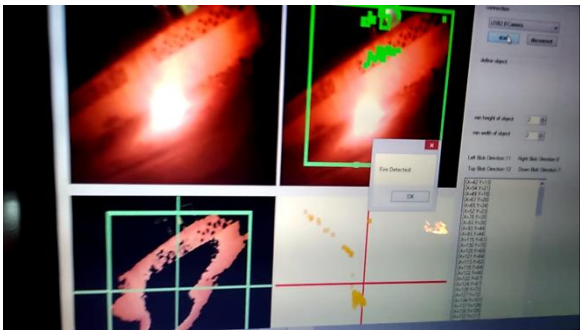

Fig. 3: Open environment 2

VI. CONCLUSION

The proposed fire detection system provides quick and efficiently true alert in case of fire emergencies. This systems works on camera footage of a surveillance system which does not need any sensors for detecting fire. Hence, we conclude that real time fire detections using multi expert system is robust and reduced the false positive results as compared to the existing system.

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