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# Review on vision based fire flame detection

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## ABSTRACT

***The break-out of a fire should be determined rapidly in order to prevent material damage and human casualties. Traditional low-level feature-based methods have a high rate of false alarms and have low detection accuracy. To overcome these issues, deep learning models for fire detection at early stages during surveillance are used. Smaller convolutional kernels and fully connected layers of the deep learning models help to do classification effectively by reducing the computational requirements.***

***Keywords***— *Flame Detection, Vision Based Systems, Deep CNN Based Classification*

## 1. INTRODUCTION

Two main approaches in the field of fire detection are conventional fire alarms and vision sensor assisted fire detection. Traditional fire alarms use sensors such as infrared and optical sensors which are not much effective in critical environments. They need human presence to confirm the occurrence of fire. Also, these systems don't provide detailed information about the fire like size, location, burning degree etc. The limitations of traditional systems can be solved by vision-based fire detection methods. Vision based approach has several advantages. They are able to detect fire without the interference of humans. These systems are also having several disadvantages. It includes the complexity of the scenes under observation, irregular lighting, and low-quality frames. Several researches have been done for solving these issues by introducing color and motion features. Most of those methods lack accuracy when tries to minimize computational requirements.

Convolutional Neural Network (CNN) can be used effectively in detecting fire with higher accuracy rate and lower computational needs. They show great performance in object detection and localization, image segmentation, classification, indexing, retrieval etc. The hierarchical structure of CNN helps in learning strong features from raw data. Fire detection is very important in fields like industrial areas, forest areas etc. After many researches, some algorithms are specially designed for this purpose. These algorithms designed till now on fire detection through videos are statistical color model, spatio-temporal flame Modeling, dynamic texture analysis, optical mass flow estimators etc. Deep learning techniques are getting much attention now a days.

## 2. FIRE DETECTION TECHNIQUES

A fire flame detection algorithm using motion estimation and color information was proposed by Dattathreya, Heegwang Kim and Jinho Park [1]. The irregular motion vectors of the fire flame are analyzed mainly. The algorithm consists of extraction of the fire candidate region in the HSI color space, motion estimation of the candidate region using an optical flow method, quantization of the motion vectors into 8 directions and detection of the region where the motion is generated in various directions as the fire area. In general, fire flame has the color value of reddish colors and color saturation of fire exhibition varying characteristics relating to the severity of fire in the image. For that reason, this method extracts the fire candidate region using HSI color space. In case of detecting fire candidate regions using only color information, there is a problem that the fire-colored object is detected as fire. In order to address this problem, the proposed method additionally uses the motion vector. In the experiment results, the fire detection method using motion vector shows more exact results than only using color information.

A method that uses Feed Forward Neural Network for classifying fire is proposed by Olga John and Shajin Prince [2]. The boundaries of the flame is detected by using an auto detection algorithm and by using resilient back propagation algorithm, classification is done by feed forward neural network. Auto adaptive edge detection algorithm finds out the principal edges and removes the unwanted ones and finally classifies the flame level as high level or low level. Gaussian filter is used for removing noise. Edge detection is done by using sobel operator. If the gradient magnitude is greater than a threshold value (TH), then it is considered as an edge otherwise not. . Another threshold TE is set to limit the total number of edges., if the number of edge pixels increases above TE, the automatic adjustment gets stopped. Here, a preliminary edge image (PEI) with edges identified is obtained from the original flame image. Unrelated edges are removed from PEI. The pixels of the longest edge are taken in the final edge image which will be having the same size as that of original input flame image. Flame image is classified based on feed forward neural network that uses resilient back propagation algorithm. The algorithm is much effective in identifying the edges of irregular flames compared with the conventional methods. In this method, the fire and flame edges detected are continuous and clear. Also, with change of scenarios, the parameters in the algorithm are auto adjusted.

 

J. Ebert and X. Qi propose a computer vision-based method for fire detection in videos [3]. The system uses a cumulative fire color matrix. Fire color of each frame is collected into it. A new color model is used here. Pigmentation values of the RGB color, saturation and the intensity properties in the HSV color space are taken into consideration. A region merging algorithm merges the nearby regions which are similar to fire. This helps to reduce false positives. The disadvantage of this method is that it is unable to detect the type of fire.

The image processing technique developed by G Marbach, Markus Loepfe and Thomas Brupbacher [4] examines the YUV-color space using motion information to detect fire in video images. Luminance of pixels near the fire is observed to have high saturation value. The method mainly uses two properties of the fire. The flickering property and the reaching of maximum luminance. It has high reliability in critical environments.

In the method proposed by Kandil and M Salama [5], a new adaptive terminal attractor algorithm is used. Fire in a sequence of images is identified by applying a hybrid algorithm depending on adapting the back-propagation algorithm. The boundaries of fire and smoke is identified using canny edge detection. Video is analyzed in wavelet domain to detect fire flicker. Variation of colors in flamed regions is found by the computation of spatial wavelet transform in moving fire regions. The hybrid algorithm is used for real time fire detection in nuclear reactors having high radiation levels.

The system proposed by Martin Mueller, Peter Karasev, Ivan Kolesov and Allen Tannenbaum [6] uses a set of motion features based on motion estimators. Fast fire motion and structured motions of other objects are examined in this method. Two optical flow methods are used to find the presence of fire. One is optimal mass transport which models fire with dynamic texture. Another one is a data driven optical flow scheme that models saturated flames. Flow magnitudes and directions are observed to determine fire and non- fire motion. These features are tested on a large video database for understanding their effectiveness.

Video Based Smoke and Flame Detection Using Convolutional Neural Network [7] proposed by GeumYoung Son and Jang-Sik Park describes a method to detect fire using deep learning. Deep learning networks used were AlexNet, GoogLeNet and VGG-16 in three ways. Image input from a closed-circuit television (CCTV) camera is classified into three different states (normal, smoke and flame). The network is then trained to identify each corresponding state. The datasets used include images coming from three areas which are housing, high-rise building, and mountain where fire incidents occurred. The quarter part of all datasets was used as test images. Half of them were used for validation, and the rest for testing purposes. Over ninety percent accuracy was shown by all three network models in classifying fire.

In the paper proposed by Naigong Yu and Yue Chen [8], a video flame detection method based on two-stream convolutional neural network combining spatial and temporal features is described. By using motion feature detection and color feature detection, the suspected flame region is extracted from the video. The two-stream convolutional neural network classifies the extracted suspected region. The region whose classification result is flame is output as the final detection result. This flame detection method is observed to be given high detection accuracy as per the results obtained.

Khan Muhammad and Paolo Bellavista [9] developed an effective method for detecting fire using Deep CNN Architecture [Fig 1]. The efficient CNN architecture inspired by the SqueezeNet architecture [Fig. 2] has multiple layers having number of filters in each layer to predict the proper result from the input data. Fine tuning of the CNN reduces the computational needs. No dense or fully connected layers are used in it. It uses smaller convolutional Kernals. Even if the computational requirements are minimum, it shows higher accuracy that is comparable to complex models.

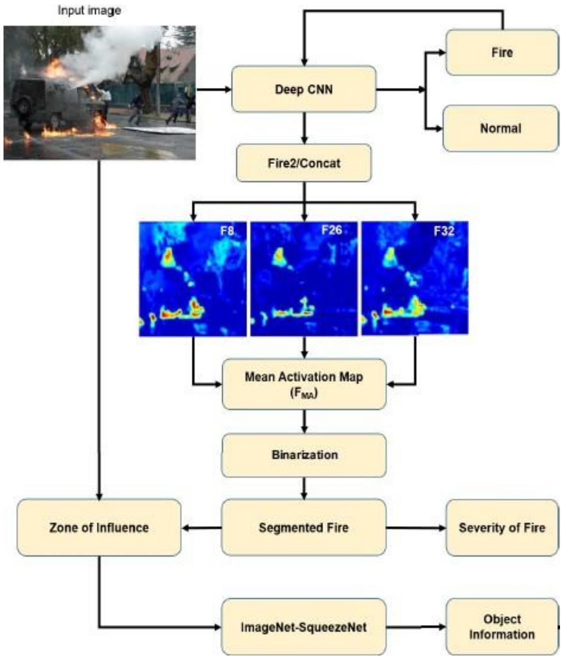


**Fig. 1: Fire localization using the deep CNN**

## 3. ANALYSIS OF DIFFERENT METHODS

Most of the flame detection techniques rely on chromatic features, dynamics etc of flame. In case of detecting fire candidate regions using only color information, there is false detection problem that the fire-colored object is detected as fire. In order to address this problem, motion vectors were used. It could improve the accuracy but still the results were not completely reliable. In chromatic detection, YCbCr model is more efficient than RCB color model. Edge detection algorithms are also used which are effective in detecting fire. Multiple features can be used together but computational requirements will be high. Classification based on feed forward neural network is not much accurate since there is no back propagation. Deep CNN based detection is highly accurate.

## 4. CONCLUSION

Intelligent CCTV surveillance systems are developed by making use of the capabilities of smart cameras. Various abnormal events such as accidents, medical emergencies, and fires can be detected using these smart cameras. Of these, fire is the most dangerous abnormal event, as failing to control it at an early stage can result in huge disasters, leading to human, ecological and economic losses. After analyzing different methods, it is observed that computationally expensive methods have better accuracy, and simpler methods compromise on accuracy and generate high rate of false positives. Hence, there arise a need to find a better approach which is highly accurate and least expensive. The Deep CNN based approach can both localize fire and identify the object under surveillance. Furthermore, the system balances the accuracy of fire detection and the size of the model using fine-tuning and the SqueezeNet architecture, respectively.

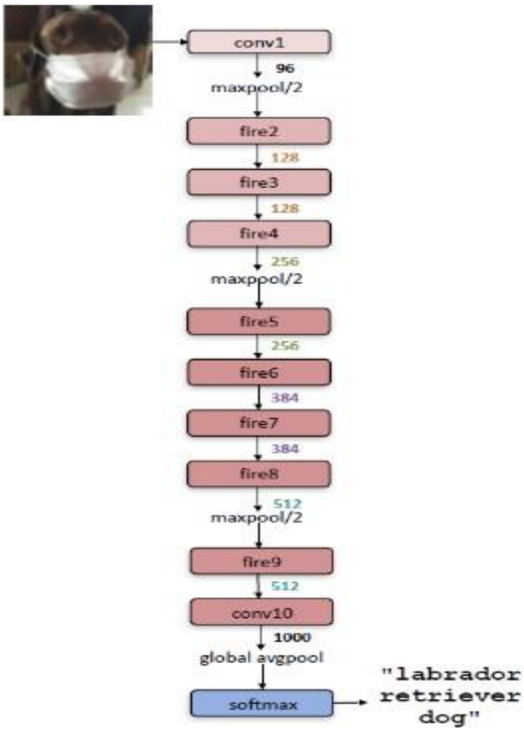


**Fig. 2: SqueezeNet Architecture**

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