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Survey on Flame Detection by Optical Flow Estimation

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Abstract —Automatic fire detection by real time vision based method got great importance in recent years. By the development in science and technologies it has drawn potential significance in last decades. There are different video based detection for smoke, fire and object's movement .The importance of fire being detected as early as possible is to take prevention and precaution before it causes any material damage, human casualties. Survey aims to study the different methods and techniques used for flame detection and some related works.

KEYWORDS: Fire Detection, Optical Flow, Optimal Mass Transport, Video Analytics, Vision-Based Method.

I. INTRODUCTION

In olden days, the people are employed as examiners or investigators for fire detection. But in those scenarios, the error rates are too high due to their low efficiency. In the case of point sensors are failed, video detection approach got high relevance. The future research in this will help for the prevention and precaution to be taken in account before it causes any material damage, human casualties [21].

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, liberating heat, light and various reaction products [1]. Flame is the visible portion of the fire. Its glow is complex. Fire can causes great and large destruction to life and property. In many cases such as burning of wood or incomplete combustion of gas usually appeared to be in red-orange glow of fire, whereas its complete combustion may have a dim blue color. There are many fire prevention and protection systems are available in order to minimize the damage and destruction resulting from a fire [27]. Conflagration is the term used for describing the great and destructive fire which may threatens the human and animal life or property. It is also mean by very intense and uncontrolled fire [28].

II. PREVIOUS WORK

Fire detection systems has got vital role in monitoring and surveillance systems which are used to detect or monitor the buildings and environment as part of early precaution or warning mechanism that notifies the start of fire. Thus the early notification can reduces the large material damage or human causalities to some extent.

In a congested automobile traffic, heavy industry or highly populated area this will be serious problem to consider with. There are many techniques used as fire detection systems. Some will be based on built in sensors which will be highly depending on reliability and the proper distribution of sensors. It should be positioned in such a way that the particles generated by fire or smoke should be reached the sensors in order to activate them. Therefore the coverage area in the case of outdoor applications makes it impractical because of the necessity of regular distribution of sensors in close proximity.

III. FIRE DETECTION TECHNIQUES

A. Fire detection using ION detectors

In this paper, [2] the author researched about the fire detection in the residential area using ION detectors. Flame ionization detectors are used widely in gas chromatography because of its number of advantages such as cost, low maintenance requirements, rugged construction, and linearity and detection ranges [3]. It is based on the principle that detection of ions formed during the combustion of organic compounds in a hydrogen flame. But it cannot detect inorganic substances. In order to achieve fault-tolerant and consistent results and high probability detection rates needs more than one sensor to be used. The discrimination of flaming and non flaming fires can be assured.

B. Analyze the video in wavelet domain

The paper [4] suggest a method by using a camera for monitoring a scene in order to detect the fire time by evaluating the video generated from it. It is done by analyzing the video in wavelet domain. The mathematical calculations and computation of spatial wavelet transform of moving fire color regions helps in identifying the color variations in the flame regions

C. Using a rule based generic color model

In the paper [5] the author proposes an algorithm which uses YCbCr color space to separate the luminance component from the chrominance more effectively. For the classification of flame pixel the author suggested to use a rule based generic color model. The image containing fire or fire like regions was taken for testing the performance. This method results in

higher rate in detection and reduces false alarm rate. Computational complexity of the algorithm is very cheap [26].

D. Fire pixel classification by fuzzy logic

Author in paper [6], uses fuzzy logic enhanced generic color model, whereas in the previous paper they used rule based generic model for pixel classification of fire. In this paper they are used instead of existing heuristic rules and thus make the pixel classification more robust. Thereby effectively discriminate fire and fire like colored objects [26]. Discrimination between fire and non fire region pixels are obtained by statistically derived chrominance model which can be represented as a region in chrominance plane.

E. Expectation Maximization & Flow Estimation Algorithm

Different estimation methods such as expectation maximization (EM), flow estimation allows parameter estimation with incomplete data using probabilistic model. EM algorithm can be defined as an alternation between the steps of guessing probability distribution over completions of missing data given the current model which is also known to be E-step. After this using the completions reestimate the model parameters which are known as M-step [12]. The second method discussed is the flow estimation which can be used to distinguish between fire and non fire motion. Algorithm uses for this extract target region which may be vague and inaccurate in case the background image not being updated in time. The extraction of target region is done due to the static state of log image. Detection makes critical in the case a forest fire lasts beyond fifteen minutes, for which a fast detection is difficult. So a different method has to be implemented for such critical situations. For example like human surveillance, infrared technology has been introduced in order to detect forest fire with thermal infrared cameras. In the scenario of a forest environment all the objects do not stand stable and still. Because of the wind and other atmospheric factors trees may be waved, so that this will be compared with moving estimation, color based segmentation is more suitable for such forest fire detection.

F. Fire identification for Early Fire Alarm Based on Optical Flow Video Processing

Fire detection based on Lucas-Kanade optical flow algorithm which has the capability of discovers the fire from real time video streaming by using a monocular camera [13]. A monocular is a modified refracting telescope used to magnify the images of distant objects by passing light through a series of lenses and sometimes prisms; the use of prisms results in a lightweight telescope [14]. Lucas–Kanade method is a differential method used for optical flow estimation. It assumes that the flow is essentially constant in local neighbourhood of the pixel under concern, and solves the basic optical flow equation for all the pixels in that neighbourhood [15].this can be applied to either indoor or outdoor areas. The highlight or important matter is it enables earlier and fast identification of presence of fire. It works by the background subtraction in order to distinguish moving pixels from others and filter it out the colors that are consistent with fire. Here the author intended to use Lucas-Kanade [16] associated with pyramid technique.

G. Evaluation and Detection of Fire Flow by SVM Classifier

Replacing the classical optical flow methods, here author put forwarding two optical flow methods. They are OMT model and data driven optical flow scheme [17].those methods are used in fire detection procedure in cooperating with EM segmentation image classification process to obtain better results. In this paper SVM is used instead of neural network influences. EM algorithm [19] is used to estimate parameters and assignments of each data points which can be obtained [17]. The algorithm begin with random parameter values for the models and it continues until those values converges to E step and M step; assign the points to the model to its best and then update the parameters by the points that are assigned to it [18]. The image classification process by SVM is performed by segmenting optimal clusters on hyper plane. Its training seem to be more robust when compared to artificial neural networks.SVM are supervised learning models with associated learning algorithms that analyze data and find the patterns, used for classification and regression analysis [20]. Given a set of training examples, each separate the training set images into one of two categories, dimensional feature space, and the class label.

H. Autonomous forest fire detection

In this paper [22] the author proposes an autonomous forest fire detection system depending upon the temporal difference of long cloud smoke with natural background. Using a binning table the collected image is converted to equal sized height and width. Two bounds or thresholds are using for the detection purposes. By considering the hardware and computational techniques the algorithm do major works in video based smoke detection. The approach shows complex behavior in the presence of slow or repetitive movement of objects [29].

I. Vision based fire detection

In 2004 the authors Liu and Ahuja [23] put forward spectral, spatial and temporal models of fire regions in visual image sequences. The spectral model is depicted in terms of color probability density of fire

pixels whereas the shape of fire region is described in terms of spatial frequency content by using its Fourier coefficients. From the results obtained it is visible that the method is capable of detecting fire reliably [29].

J. Fire and smoke detection without using sensors

In 2007 Turgay, Huseyin & Hasan [24] suggested an algorithm for color analysis and motion detection related on different color models for fire and smoke detection. The samples extracted from images is taken for statistical analysis and based on this acquired these color models. This can't be an appropriate method for the detection of smoke in the case of varying colors since the simple motion detection technique has high false alarm rates [29]. This system suppose that at the beginning of fire would produce a particular range of colors and it appears to be in different range of color when the fire progress.

TABLE 1: Comparison Between Different Fire Detection Techniques

No	Approaches	Advantages	Limitations
1	Fire detection using ION detectors	Low cost & maintenance requirements, Rugged construction, Linearity & Detection ranges, Discrimination of flaming & non flaming fires is assured	Cannot detect inorganic substances, More than one sensor is to be used for achieving fault tolerant and consistent result and also for high probability detection rates.
2	Using a rule based generic color model	higher detection rate – 99%, System is cheap in computational complexity & more robust to illumination changes	Not taking accounts the flickering nature of time.
3	Fire pixel classification by fuzzy logic	Frame processing rate of detector = about 40fps and Detection rate = 98.89%	Error in detection occurs when there is sudden change in lighting conditions.
4	Fire detection using Optical flow estimation	Distinguish fire image from non fire images	Little false detections are observed in the presence of noise, partial occlusions & rapid rotational motion
5	Vision based fire detection	Fire detection is reliable	Fourier Descriptors are sensitive to noise

IV. CONCLUSION

By using different fire detection techniques, many of the vision based approaches are still susceptible to false alarms. So there is a technique called optical flow estimation for flame detection. In this method detecting fire using optical mass transport and non smooth data models instead of using classical optical flow methods mentioned in literature survey. For two reasons that makes unable to use classical optical flow models are intensity constancy and smoothness regularization [9]. These two are not always preserved due to the fire characteristics. Since fire blobs are expected to have non smooth boundary motion, NSD is chosen to be non smooth. There comes the necessity to identify the presence of flame in the images from real time video capturing based on set of features obtained from the optical estimation by OMT and NSD. The basic idea to be taken in account is the difference between tempestuous, fast fire motions. This review will help for performing comparative analysis which will be very useful for further research**.**

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