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Fire Detection using Computer Vision: Survey and Analysis

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Abstract: Due to high fire occurrence and massive damage, the early fire detection is happening more and more important. Because of the advance development of image processing technology, image becomes more and more widely an application of fire detection technology. This paper examined the fire detection methods based on images in recent years. Based on the review, it is clear to see that if the optimal algorithms can be adopted for each part of detecting motion area and extracting fire characteristics, the accuracy of the fire alarm on real-time as well as the system performance can be improved.

Keyword: - Computer Vision, Fire Detection, Image Processing.

INTRODUCTION

Fire detection systems are the most essential factor in surveillance systems used to monitor buildings and the environment. As part of an early warning mechanism, it is preferable that the system has the capacity to report the earliest stage of a fire. Currently, almost all fire detection systems use built-in sensors that depend primarily on the reliability and the positional distribution of the sensors. It is essential that these sensors are distributed densely for a high precision fire detection system. In a sensor-based fire detection system for an outdoor environment, coverage of large areas is impractical due to the necessity of a regular distribution of sensors in close proximity. Due to rapid developments in digital camera technology and video processing techniques, there is a major trend to replace conventional fire detection methods with computer vision based systems. In general, computer vision-based fire detection systems employ three major stages: fire pixel classification, moving object segmentation, and analysis of the candidate regions. This analysis is usually based on two figures: the shape of the region and the temporal changes of the region [1]. The fire detection performance depends critically on the effectiveness of the fire pixel classifier which generates seed areas that the rest of the system will exercise. The fire pixel classifier is thus required to have a very high detection rate and preferably, a low false alarm rate. There exist few algorithms which directly deal with the fire pixel classification in the literature [2].

The motivation for an image processing based approach is due to rapid growth of the electronics. Fire detection systems are one of the most important components in surveillance systems used to monitor buildings and environment as part of an early warning mechanism that reports preferably the start of fire. Currently, almost all fire detection systems use built-in sensors that primarily depend on the reliability and the positional distribution of the sensors. The sensors should be distributed densely for a high precision fire detector system. In a sensor-based fire detection system, coverage of large areas in outdoor applications is impractical due to the requirement of regular distribution of sensors in close proximity. Due to the rapid developments in digital camera technology and video processing techniques, there is a big trend to replace conventional fire detection techniques with computer vision-based systems. There are different characteristic parameters of fire i.e. color, smoke, Area and motion using image processing in MATLAB can be analyzed. Along with this monitoring of temperature and Humidity of fire is done for more precision [3].

Figure 1: Fire Detection System.

II SURVEY ON FIRE DETECTION

Due to the rapid development of digital camera technology and advanced content based image and video processing, there is a major trend to replace conventional fire detection system with computer vision based system. There are several research have been done in this area. This includes:

Chen et al [4] proposed an algorithm of early fire image detection and identification based on Discrete Fractal Brownian Incremental Random Field model (DFBIR). Initially, the high-brightness regions with colors that match the flame color model are identified (YUV model). Then the differential model is used to analyze if the identified fire region extends. Finally, the DFBIR model is used to further detect and identify early fire image. The algorithm can exclude the mendacious fire and detect the real fire. Adding DFBIR algorithm in the last step improves the accuracy from 95% to 99% but increases the time complexity.

T. Celik and Hasan Demirel et al. [5] further enhance system that uses a statistical color model with Fuzzy logic for fire pixel classification. The proposed system develop two models; one based on luminance and second based on chrominance. Fuzzy logic uses the YCbCr color space for the separation of luminance from chrominance instead of using color spaces such as RGB. Existing historic rules are replaced with the Fuzzy logic to make the classification more robust and effective. This model achieves up to 99.00% correct fire detection rate with a 9.50% false alarm rate.

Krull et al. [6] used low-cost CCD cameras to detect fires in the cargo bay of long range passenger aircraft. The method uses statistical features, based on grayscale video frames, including mean pixel intensity, standard deviation, and second-order moments, along with non-image features such as humidity and temperature to detect fire in the cargo compartment. The system is commercially used in parallel to standard smoke detectors to reduce the false alarms caused by the smoke detectors. However, the statistical image features are not considered to be used as part of a standalone fire detection system.

Marbach et al. [7] used YUV color model for the representation of video data, where time derivative of luminance component Y was used to declare the candidate fire pixels and the Chrominance components U and V were used to classify the candidate pixels to be in the fire sector or not. In addition to luminance and chrominance they have incorporated motion into their work. They report that their algorithm detects less than one false alarm per week; however, they do not mention the number of tests conducted.

Celik et al. [8] used normalized RGB (rgb) values for a generic color model for the flame. The normalized RGB is proposed in order to alleviate the effects of changing illumination. The generic model is obtained using statistical analysis carried out in r–g, r–b, and g–b planes. Due to the distribution nature of the sample fire pixels in each plane, three lines are used to specify a triangular region representing the region of interest for the fire pixels. Therefore, triangular regions in respective r–g, r–b, and g–b planes are used to classify a pixel. A pixel is declared to be a fire pixel if it falls into three of

the triangular regions in r–g, r–b, and g–b planes.
Celik et al. [9] proposed a novel model for detection of fire and smoke detection using image processing approach. For fire detection the proposed method uses RGB and YCbCr color space. Few rules are identified to fire pixels, and then given to a Fuzzy Inference System (FIS). A rule table is formed depending on the probability value the pixel is considered to be fire. They report to have 99% accuracy but, this cannot be used for real time monitoring. In case of smoke detection they have given some threshold values but, this method may fail because the texture of smoke varies depending on the materials which are burned.

R. Gonzalez-Gonzalez et al. [10] proposed a method to detect fire by smoke detection based on wavelet. In this smoke detection method, image processing on video signals is proposed. The SWT transform is used for the area detection of ROI's. This method comprises of three steps. In the first step, preprocessing is performed and the image is resized and transformed to grayscale image. Finally indexed the image using indexation. The second step involves high frequencies of an image is eliminated using SWT and reconstruct the image by inverse SWT. In order to group the intensity colors that are closed to each other is the main purpose of image indexation. Histogram analysis is used to determine the indexation levels. After that compare the image with a non-smoke frame and selecting those pixels that are change from one scene to another. The final stage consists of smoke verification algorithm in order to determine whether ROI is increasing its area and to reduce the generation of false alarm. These three steps are combined together to form the final result.

Hidenori Maruta et al.[11] proposed another method for smoke detection based on support vector machine. In this approach robust and novel smoke detection method is proposed using support vector machine. Firstly preprocessing is performed by extracting moving objects of images. The preprocessing consists of five steps: image subtraction and accumulation, image binarization, morphological operation, extraction of Feret's regions and creation of the image mask. Image subtraction is used to extract regions

of moving object. In order to eliminate noise like regions binarization and morphological operations are used. The position and approximated shape of the object is obtained by identifying Feret's diameter is called feret's region. After preprocessing, perform texture analysis and extract the texture features. These texture features become the component of feature vector. Feature vector is applied as the input vector and support vector machine is used to classify smoke or not. Smoke detection method involves three steps: analyzing texture features, discrimination of Feret's region using support vector machine and time accumulation. In order to extract feature vectors of the image, texture analysis is performed in this method. Support vector machine is used to classify smoke or non- smoke from the extracted image. The main advantage of this method is that more accurate extraction of smoke areas in image can be obtained using SVM.

Y. Habiboglu et al. [12] proposed another method that uses covariance descriptors for fire detection. In this method, color, spatial and domain information are combined by using covariance descriptors for each spatio-temporal block. The blocks are generated by dividing the flame colored region into 3D regions. This method used a covariance matrix for the detection of flames. Background subtraction method is not used in this approach. To detect fire, divides the video into spatio temporal blocks and covariance features are computed from these blocks. Using an SVM classifier, the flame colored region are classified by using the spatial and temporal characteristics. These classified flame colored In order to define spatial-temporal blocks temporal derivatives are calculated along with spatial parameters. Spatial temporal blocks can be defined using covariance matrices. Then compute the covariance values of the pixel property vectors in spatio-temporal blocks. For classification, support vector machine is trained. According to the number positively classified video blocks and their positions, confidence value is determined for fire detection. This method is computationally efficient. Covariance approach is well suited for detection of flames. Drawback of this method is that, it is well suited when the fire is clearly visible. If the fire is far away from the camera and covered with dense smoke, this method performs poorly.

Mehdi Torabnezhad et al. [13] proposed another method that used image fusion technique to detect smoke. In this method, combine visual and thermal information to improve the rate of fire detection. The invisibility of smoke in LWIR image can distinguish smoke from smoke like objects. Infrared images do not detect smoke in the images but can detect smoke like object.. Integrating these images give correct information about smoke. Objective of their paper is to save people, forest from the fire. By this method generation of false alarm can be reduced to a great extent. The proposed algorithm consists of two phases. In the first phase combine visual and thermal information of the smoke and potential smoke mask is generated. PSM is again analyzed to differentiate true and false alarms. This method is very efficient and detects smoke successfully. Improves the fire detection rate and reduces the generation of false alarm. The drawback of this method is Correct and punctual detection of fire is not possible and comparison is required to identify smoke.

Soe et al. [14] used the static image characteristics of the light blue flame to detect fires. The image is grabbed in the memory and fire-suspected regions are defined by using the region of interest (ROI) technique. The blue flame character pixels which are commonly found in gas fire are then checked in each ROI by using color intensity composition detection algorithm. If at least one ROI has the threshold amount of blue flame character pixels, this ROI is assumed to have a fire breakout. Furthermore, the average light intensity of the whole image is also calculated in order to use different threshold values of the blue flame for different background lights. This method can detect the gas fire flame with a less number of false alarms. But with only one feature to test fire also has some limitations. Since the conventional smoke-based fire detectors tend to exhibit high false alarm behavior.

Wang et al. [15] introduced a kind of the new method of extraction flame object based on the threshold of the area. Firstly, adaptive threshold generated by iterative method is used to segment the image. Secondly, they use knowledge of set theory to extract object contour. Finally, it can judge whether fire occurs from the fire flame color, fire spreading etc characteristic information.

Lei, Wanzhong et al. [16] analyzed the status in the fire detection technology, and designs a structure to detect the early fire in coalmine. Firstly, image which comprises the potential fire region the potential fire region is detected by using frame differencing of monitor video, and denoised by median filter. Secondly, flame region is extracted by color information. Finally, Bayes classifier is employed to recognize fire combined with the dynamic features.

K. Poobalan et.al. [17] proposed a fire detection algorithm based on image processing techniques which is compatible in surveillance devices like CCTV, wireless camera to UAVs. The algorithm uses RGB colour model to detect the colour of the fire which is mainly comprehended by the intensity of the component R which is red colour. The growth of fire is detected using sobel edge detection. Finally a colour based segmentation technique was applied based on the results from the first technique and second technique to identify the region of interest (ROI) of the fire.

Nurul Shakira Bakri et.al. [18] Proposed the algorithm of fire detection using image processing techniques i.e. colour pixel classification. This Fire detection system does not require any special type of sensors and it has the ability to monitor large area and depending on the quality of camera used. The objective of this research is to design a methodology for fire detection using image as input. The propose algorithm is using colour pixel classification. This system used image enhancement technique, RGB and YCbCr colour models with given conditions to separate fire pixel from background and isolates luminance from chrominance contrasted from original image to detect fire.

III CONCLUSION

Since fires can do so much damage and have devastating consequences, great efforts have been put into the development of systems for their early detection. From the review of above literatures, we have analysized that the majority fire detection methods encounters several problems, which includes the video image acquisition method, a motion area identification techniques and the feature extraction algorithms of fire that contains the characteristics of fire. If the best possible algorithms in all these aspects are taken on, the recognition rate, real-time and anti-interference ability of flame detection will be improved.

REFERENCE:-

[1]. E.Kuhrt, J.Knollenberg, V.Mertens. “An Automatic Early Warning System for Forest Fires”. Annals of Burns and Fire Disasters, vol. XIV, pp.151-154, 2001.

[2]. L. Yu, N. Wang, X. Meng, “Real-time Forest Fire Detection with Wireless Sensor Networks”, Proceedings of International Conference on Wireless Communication, Networking and Mobile Computing, vol.2, pp.1214-1217,2005.

[3]. Z. Li, S. Nadon, J. Cihlar, “Satellite detection of Canadian boreal forest fires: development and application of the algorithm,” International Journal of Remote Sensing, vol. 21, no. 16, pp. 3057- 3069, 2000.

[4]. T. Chen, P. Wu, and Y. Chiou, “An Early Fire-Detection Method Based on Image Processing,” Proc. IEEE Int. Image Process., 2004, pp. 1707-1710.

[5]. Celik, T., Demirel, H., Ozkaramanli, H., Uyguroglu, M., “Fire Detection in Video Sequences Using Statistical Color Model”, Proc. Internat. Conf. on Acoustics, Speech, and Signal Processing, vol. 2,no.pp. II-213 - II-216, May 2006.

[6]. W.Krull, I.Wıllms, R.R.Zakrzewskı, M.Sadok, J.Shırer, B.Zelıff, “Design and test methods for a video-based cargo fire verification system for commercial aircraft”, Fire Saf. J. 41(4), pp. 290–300, 2006.

[7]. G.Marbach, M.Loepfe,T.Brupbacher, “An image processing technique for fire detection in video images”, Fire Saf. J. 41 (4), pp. 285–289, 2006.

[8]. T.Celik, H.Demirel, H.Ozkaramanli, “Automatic fire detection in video sequences”, Proceedings of European Signal Processing Conference, September 2006.

[9]. Turgay Celik, Huseyin Ozkaramanli, Hasan Demirel,” Fire Pixel Classification Using Fuzzy Logic and Statistical Color Model”, ICASSP 2007.

[10]. R. Gonzalez-Gonzalez, V. Alarcon-Aquino, R. Rosas-Romero, O. Starostenko, J. Rodriguez-Asomoza,” Wavelet-Based Smoke Detection in Outdoor Video Sequences”, 53rd IEEE International Midwest Symposium on Circuits and Systems (MWSCAS), 2010.

[11]. Hidenori Maruta,Akihiro Nakamura,Fujio Kurokawa, “A Novel Smoke Detection Method Using Support Vector Machine “,TENCON - IEEE Region 10 Conference, 2010.

[12]. Habiboglu, Y.H., Gunay, O. and Cetin, A.E. "Flame Detection Method in Video Using Covariance Descriptors," in the proceeding of IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), May, 2011. DOI: 10.1109/ICASSP.2011.5946857.

[13]. Mehdi Torabnezhad, AliAghagolzadeh, HadiSeyedarabi, “Visible and IR image fusion algorithm for short range smoke detection,” IEEE International Conference on Robotics and Mechatronics, 2013.

[14]. Soe, Aung Kyaw, Zhang, Xianku. “Fire detection by static image characteristics of the light blue flame using roi-based color intensity composition detection algorithm”. ICIC Express Letters, December Vol.5, No.12, 2011, pp. 4479-4486.

[15]. Wang, Wenhao, Zhou, Hong. “Fire detection based on flame color and area”. CSAE 2012 Proceedings, 2012 IEEE International Conference on Computer Science and Automation Engineering 2012, pp. 222-226.

[16]. Lei, Wanzhong, Liu, Jingbo. “Early fire detection in coalmine based on video processing”. Advances in Intelligent Systems and Computing, Vol. 181, 2013, pp. 239-245.

[17]. S.-C. L. Kumarguru Poobalan, "Fire Detection Algorithm Using Image Processing Techniques," 2015.

[18]. Nurul Shakira Bakri, Ramli Adnan, Abd Manan Samad, Fazlina Ahmat Ruslanm, “A Methodology for Fire Detection Using Colour Pixel Classification “,IEEE 14th International Colloquium on Signal Processing & its Applications (CSPA 2018), 9 -10 March 2018, Penang, Malaysia.