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A New Approach to Vision-Based Fire Detection Using Machine Learning

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ABSTRACT
Computer vision - based fire detection has recently attracted great deal of attention from the research community. In this paper, the authors propose and analyses a new approach for identifying fire in videos. Computer vision techniques are largely used now a days to detect the fire. There are also many challenges in judging whether the region detected as fire is actually a fire this is perhaps mainly because the color of fire can range from red yellow to almost white. So fire region cannot be detected only by a single feature color many other features have to be taken into consideration. This paper is a study of the recent techniques and features extracted by different existing algorithms. In this approach, we propose a combined algorithm for detecting the fire in videos based on the changes of the statistical features in the fire regions between different frames. The statistical features consist of the average of the red, green and blue channel, the coarseness and the skewness of the red channel distribution. These features are evaluated, and then classified by Bayes classifier, and the final result is defined as fire-alarm rate for each frame. Experimental results demonstrate the effectiveness and robustness of the proposed method. There is different method which focuses on various properties of fire like, color, shape, movement, spatio-temporal features etc. For real-time identification of fire from videos simple and accurate method is proposed as multi expert system, which uses color, shape and movement evaluation for detecting fire. The study refers different methods for fire detection and prefers integration of smoke analysis for early identification of fire.

KEYWORDS: Fire detection, Pattern recognition, Bayes classification, Flame feature, Probabilistic model, statistical Features of Fire Regions

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I. INTRODUCTION

Two main applications of vision-based fire detection are: (1) monitoring fires and burn disasters from surveillance systems [1], and (2) automated retrieval of events in newscast videos [2]. These applications play an important role in modern society. Recently, there have been a number of efficient methods proposed for vision-based fire detection in[1]-[6].In [1], Chao-Ching Ho analyzed the spectral, spatial and temporal characteristics of the flame and smoke regions in the image sequences. Then, the continuously adaptive mean shift vision tracking algorithm was employed to provide feedback of the flame and smoke real-time position at a high frame rate. P. V. K.Borges and E. Izquierdo, in [2], analyzed the frame-to-frame changes of specific low-level features such as color, area size, surface coarseness, boundary roughness, and skewness within estimated fire regions to describe potential fire regions and used Bayes classifier to indicate a frame contains fire or not. In [3], CelikT. et al. developed two models, one for fire detection and the other for smoke detection. For fire detection, the concepts from fuzzy logic were used to make the classification fire and fire-like colored objects. For smoke detection, a statistical analysis was carried out using the idea that the smoke shows grayish color with different illumination. In [4], the authors also used a probabilistic metric to threshold potential fire pixels

Since the fire causes serious damages, fire detection has been an important study to protect human life and surroundings. As the economy develops, number of large buildings also increases. If fire happens in these buildings then there will be a bad social impact, major property damage and heavy casualties will be easily caused. So fire should get detected early for extinguish and evaluation. In large buildings, rooms and outdoor places, fire detectors can hardly detect fire characteristic parameters like temperature, vapor

and flame in the early time. First step to prevent the serious damages from fire is to detect the event properly. Various methods are there to detect fire which uses different properties of fire. An-other difficulty is to properly identify the characteristics of fire. The fires properties like color, shape, temporal energy, spatial characteristics are identified in different methods. The traditional methods use sensors to detect the fire which cannot be used for early detection. So video based or computer vision based methods are more appropriate for analysis. The fire properties can be identified effectively while analyzing videos. One of the most common problems found in the area of video technology for fire detection is that early identification of fire and its properties. The main causes of fire may be burning things, wildfire, and accidents so on. To detect these fires an efficient methodology is needed as early fire detection system. Fire detection is a key point in security systems. As the system performs, it must detect the fire as early as possible. Early detection of fire in a large area is a difficult task. To identify the properties of fire is also one of the important steps. The fire and fire colored objects are to be distinguished properly.

This was achieved by multiplying the probabilities of each individual color channel being fire. Habiboglu et al. proposed video-based fire detection method, in [6], which used color, spatial and temporal information by dividing the video into spatiotemporal blocks and used covariance-based features extracted from these blocks to detect fire. However, when the flickering behavior of flames cannot be visible in video, the method might perform poorly. The majority of the vision-based fire detection methods employ some type of hybrid model combining color, geometry and motion features. In general, fire detection systems first use some key features as a precondition to generate seed areas for candidate fire regions, then use the other features to determine the existence of fire in candidate fire regions. In most existing approaches, the color information and their derived descriptors like area size, surface coarseness, boundary roughness and skewness were mainly used for classification features[2]. However, using the color channels are not reliable enough to perform classification. Similarly, the classifying tasks based on the features derived from the color information cannot perform properly. In contrast to some works, we propose a new approach to solve the problem of fire detection by determining motion region, then this region is used to establish a vector of fire features. Bayes classifier uses the vector to indicate the motion region is contained fire or not. The number of detected fire regions in a frame is used to compute fire-alarm rate of the frame.

II. STATISTICAL FEATURES OF FIRE REGIONS

Intuitively, fire has some unique visual signatures such as color, geometry, and motion. Some proposed methods use these characteristics as interdependent parameters, for example, area size, boundary roughness, coarseness, skewness in[2] depended on definition of color. In this proposal, the authors evaluate these visual signatures of fire as independent features. A potential fire region is determined as a motion region. The statistical features in potential fire region include color, skewness of red channel histogram, and surface coarseness. In this paper different method for fire identification is studied. Initially the candidate region is to be identified to reduce the computation. From the analysis candidate region identification can be done based on background subtraction. The background subtraction gives a better result for identifying the moving object in the scene. Then the next step is to identify the fire region based on the candidate image block. From different methods studied color analysis gives almost true result for identification of fire region.

III. COMPARITIVE STUDY

A. COLOR CONTEXANALYSIS BASED EFFICIENT REAL-TIME FLAME DETECTION ALGORITHM

In this paper [Huan. Li, Shan. Chang, Lipng. Shao] designed a novel algorithm for fire detection in video for the industrial application which they named as Color Context Analysis based Efficient Real-time Flame Detection Algorithm (CCAFDA). The algorithm uses flame detection context based dynamic feature row vector and optical flame feature area vector to select the flame region in a frame. In this algorithm only flame feature area of each frame is considered and not the pixel features of the entire pixels in each frame. The algorithm scans pixels of the frame selectively which reduces the computational cost. But there are some conditions that need to be satisfied for the algorithm to function properly. One of the important condition among them is that, the flame should be stable and symmetrical in nature and the flame will not be extinguished suddenly. The main idea of the CCAFDA algorithm is that the position of the flame of the furnace will be concentrated over a particular region and hence there is no need to scan each pixels of each frame to get the fire region. In order to get the flame region initially the whole pixels of the first frame are scanned and when the flame region is detected the next flame onwards only

the scanning is done in the detected region. The area of the flame region is checked in each frame and if the area goes down below the desired threshold which may be because the flame has extinguished then an alarm is produced that makes the workers alert. Each time when the flame area goes down below the threshold then for the next frame scanning is done for the entire image to detect the new flame region. The main advantage of this algorithm is that only the optimal flame area is scanned in each frame except for the first frame and hence it reduces the computational time and increases efficiency.

B. A PROBABLISTIC APPROACH FOR VISION-BASED FIRE DETECTION IN VIDEOS

In this paper [Paulo ViniciusKoerich Borges and EbroulIzquierdo] have proposed a probabilistic model for detecting the fire. The method proposed is applicable in surveillance application and aim of this paper is not identifying the fire pixel but to determine if fire is present in the video. Here frame-to-frame changes of features are analyzed for detecting the fire in a video. The initial step is creating a potential fire region and then the features are extracted from this region. The features described in this paper are color, surface coarseness, and randomness of area size, boundary roughness and skewness. For a fire region the randomness of area size is large as compared to the non-fire region. The variance is the factor that describe the surface coarseness property of fire. The fire region show more amount of surface coarseness than non-fire region and this is because of the rapid change of pixel value in the fire region. While in case of skewness the fire region shows high negative value in the red channel. The values of each of these features are evaluated for different regions that is fire and non-fire regions to determine the threshold value for each of them. And then based on this threshold value the Bayes classifier recognizes whether the detected region is a fire or not. The main advantage of method used in this paper is that the features used are simple statistical features of fire and hence allows fast processing

C.A NOVEL WAY FOR FIRE DETECTION IN VIDEO USING HMM

In this paper [Jian Ding and Mao Ye] have concentrated their work to complex environment where the burning of fire is more irregular. The first step in this method is detecting the candidate region, the candidate region refers to the common region resulting from both motion region and fire colored pixel region. For motion extraction background subtraction is used and all the process is done in RGB color space. The second step was arranging the control points to get the flickering character of burning fire, these are the points along the contour regions of the candidate area. By setting a threshold value the control points are checked that it belongs to fire area or a non-fire area. The final step in this paper is Flame Flickering model by HMM. Here the final sequence obtained in the previous step is used for training the HMM parameters. Recognition of each control points from the boundary of the candidate region are done and finally a threshold value is obtained which helps in distinguishing the fire and non-fire points

D.SPATIAL-TEMPORAL STRUCTURAL AND DYNAMIC FEATURES FOR VIDEO FIRE DETECTION

In this paper [Hongcheng Wang, Alan Finn, OzyurtErdinc and Antonio Vincitore] Spatial-Temporal features of fire is extracted for fire detection and is designed for surveillance application. There are mainly three modules involved in the detection of fire: Pixel-Level processing, Blob-Level Feature Extraction and SVM classifier. The initial stage is similar to that described in the previous paper. Here the blob regions are formed from Motion Extraction and Hot Spot Detection. For motion extraction unlike from the simple background subtraction frame differencing method Adaptive Gaussian Mixture model is used here. Hot spot detection is done in HSI model where the high intensity regions are segmented. The common of both the regions that is the Blob region is found by connected component analysis. The next step Spatial –Temporal feature extraction is done from this blob region. The Spatial –Temporal feature include both Spatial –Temporal structural feature and Spatial –Temporal contour dynamic feature. In Spatial-Temporal Feature extraction the blobs obtained are observed for a period of time T, through this period of time the statistics of motion and structural patterns of blob are obtained. For this purpose two patterns are generated: Accumulated Motion Mask (AMM) and Accumulated Intensity Template (AIT). These patterns captures two important properties of fire i.e. flickering pattern and ringing structure of flame. For Accumulated Motion Mask, the motion mask is obtained from background subtraction method and it captures the flickering properties of fire. Accumulated Intensity Template is found by averaging the intensity region of the motion mask for a particular interval of time and it captures the ringing structure of flame which occurs due to the temperature variations in different regions of fire.

Fire detection

Beyond classification of video content for search and retrieval, fire detection usually finds application in surveillance and related security systems .The majority of the vision-based fire detection systems employ some type of hybrid model combining color, geometry and motion information. In general, fire detection systems use color clues as a precondition to generate seed areas for possible fire regions. A growing interest in the topic, there is still not a large number of papers about fire detection in the computer vision literature. Many fire detection systems are based on satellite images or thermal analysis of satellite sensors

Probabilistic pattern recognition

The type of flames considered (hydrocarbon flames), it is noticed that for a given fire pixel, the value of red channel is greater than the green channel, and the value of the green channel is greater than the value of blue channel

Be very permissive and many non-fire regions may be included in the PFM. For this reason, additional analysis is necessary to further refine the results. To define a real burning fire, in addition to using chromatics, statistical and dynamic features are usually adopted to distinguish other fire aliases

Significantly improve

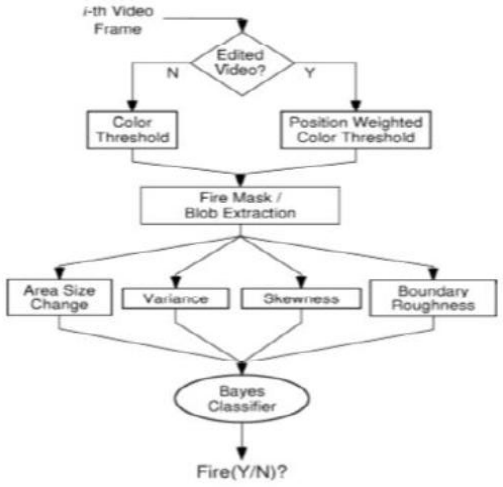
To exploit this characteristic, we use of the third order statistical moment (skewness) of the potential fire region as a feature. This is a simple and powerful discriminant, which significantly enhances the detection performance .The value of one of the channels is not very close to the expected stochastic mean for that channel, the result of the metric is significantly decreased, increasing the number of false-negatives.it is very hard to describe its texture with any given model. The randomness observed in fire can vary significantly in frequency response (periodicity is often not present) and gradient angles, for example. The variance is a well-known metric

Video processing

The fire region is usually located in the center of the frames. This fact is used to model the probability of occurrence of fire as a function of the position, enhancing the performance of the algorithm .The skewness, in particular, is a very useful descriptor because of the frequent occurrence of saturation in the red channel of fire regions. Also, we have proposed modifications to motion based features. For newscast videos, we model the probability of occurrence of fire as a function of the position, yielding an efficient performance.

IV. LITERATURE SURVEY

In [1] Paulo ViniciusKoerich Borges and EbroulIzquierdo, proposed a new identification metric based on color for fire detection in videos. Also identified important visual features of fire, like boundary roughness and skewness of the fire pixel distribution. The skewness is a very useful descriptor as the frequent occurrence of saturation in the red channel of fire regions is identified (figure 1). For newscast videos, model the probability of occurrence of fire as a function of the position, yielding an efficient performance.



While comparing with other methods which extract complicated features, the features discussed here allow very fast processing, making the system applicable not only for real time fire detection, but also for video retrieval in news contents, which require faster than real-time analysis.

In [2] Osman Gunay, BehçetUgurToreyin, KivancKose, and A. Enis Cetin, an EADF is proposed for image analysis (figure 2). In this work assumed that several sub algorithms are combined to get the main algorithm for a specific application. Each of the sub algorithm yields its own decision to representing its confidence level. Decision values are combined with weights, updated online by using no orthogonal e-projections onto convex sets describing sub-algorithms. This framework is applied to a real time problem of wildfire detection. The proposed adaptive decision fusion method uses the feedback from guards of forest which is a limitation for the system.

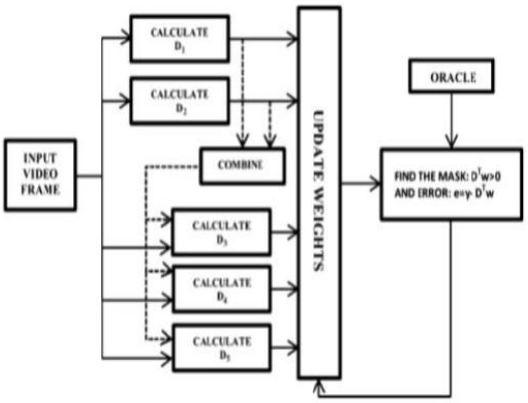


Fig -2: Flowchart of the weight update algorithm for one image frame[2].In [3] Martin Mueller, Peter Karasev, Ivan Kolesov, and Allen Tannenbaum proposed two novel optical flow estimators, optimal mass transport (OMT) and Non-Smooth Data(NSD). The dynamics of fire have motivated the use of motion estimators to differentiate fire from other non-fire object. The obtained moving region provides usefulspace on which to define motion features. These features reliably detect fire and reject non-fire motion, on a large dataset of videos. There is a chance for false detections in the presence of significant noise, partial occlusions, and rapid angle change. In [4] Kosmas Dimitropoulos, Panagiotis B armpoutis and Nikos Grammalidis, proposes a fire-flame detection to be used by an early fire detection and warning system (figure 3). The first step is to identify candidate fire regions using background subtraction and color analysis. Then the fire features are modelled by using various patio-temporal features such as color, flickering, spatial and spatial temporal energy. Dynamic texture analysis is used in each candidate region. The robustness of algorithm can be increased by estimation spatial-temporal consistency energy of each candidate fire region by comparing current and previous frames. The last step is to classify candidate region using classifier

Fig -3: An algorithm for modeling both the behavior of the fire using various spatial temporal features and the temporal evolution of the pixels' intensities in a candidate image block through dynamic texture analysis[4].In [5] Pasquale Foggia, AlessiaSaggese, and Mario Vento, proposes a method that is able to detect fires by analyzing videos. It introduce complementary information, based on color, shape variation, and motion analysis, and combined using a multi expert system known as MES. A descriptor based on a bag-of-words approach has been proposed to represent motion of objects.

V. METHODOLOGY

The aim of the paper is to generate a better system for the detection of fire flame in real time. By using previously proposed method and by proposing new techniques the better detection rate can be achieved by less consumption of time. The proposed algorithm is used to generate a robust system by using all the three algorithms. i.e. fire color detection (HSV), motion and edge detection combined.

Motion Detection: Motion analysis acts an important role due to increase in demand vision based image interpretation. Movement in a video can be detected by motion detection. Analyzation of difference in images of video frames is done. An adaptive background subtraction method is used for detecting the sudden lightning conditions and to generate foreground mask. Adaptive background subtraction maintains background model and parameters of background model evolve over time.

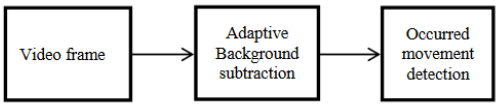


Fig.1. Block Diagram of Motion Detection System

In the above figure, frame of a video is input to the adaptive subtraction block. A subtraction between the present frame and background model is performed. After subtraction the image is segmented by threshold values. Then comparison is done between pixel and threshold value. Pixel value > Threshold value, then represent 1 i.e. whitePixel value < Threshold value,thenrepresent0 i.e. BlackMoving object is detected by white i.e. Foreground and remaining black i.e. background. Advantages of adaptive background subtraction is that a different threshold can be selected for each pixel and thus the pixels can be adaptive with time, objects become part of background without the destruction of current background and speedy recovery.

Color Detection: -Color detection is used to detect any occurrences of fire in a video. Using OpenCV model, a Color Detector model is built based on this block diagram

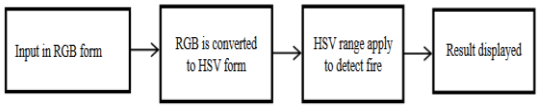


Fig 2 Block Diagram of Colour Detection System

Normally the input is in RGB form, and then RGB form is converted to HSV form. Then the range representing HSV form of fire is applied to

detect only fire characteristics. Fire in HSV form is then displayed . HSV color space is chosen purposely because it has ability to differ illumination information from chrominance more effectively than the other color spaces. Threshold values for the fire are loaded in to the system, as par the threshold values color detection system display result only if the fire is detected. In Color Basics section hue is directly corresponded to the concept o hue. The advantages of using hue is the relation between tones around the color circle can be identified easy way also Shades, tints, and tones can be generated easily without affecting the hue. Saturation corresponds directly to the concept of tint in the Color Basics section, except that full saturation produces no tint, while zero saturation produces white, a shade of gray, or black. Value corresponds directly to the concept of intensity in the Color Basics section. The advantage of HSV is that each of its attributes is directly corresponded to the basic color concepts, which makes it conceptually simple.

Edge Detection: Edge is boundary between two zones .the chemically reacted and non-thermo chemically reacted zone. Mathematical representation of first order and second purchase derivatives is utilized for analyzation of detection of edge. Gradient is found by first order and magnitude of sting is allowed by second order. Detection of the coarse and superfluous edge in the flame image is the main motive. Mostly and widely used edge detection methods like Sobel, Laplacian and Canny methods are applied with proper parameters for processing of genuine images of flame

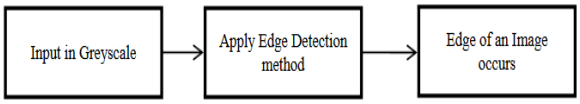


Fig.3 Block Diagram of Color Detection System

In the above diagram input image is in grey scale form, as grey form provides a good structure of animate, then an edge detection techniques are applied to give edges of images. Morphological Operations: Morphological operations like smoothing, filtering, erosion, dilation, thresholding have been used in each above methods to make system robust and effective to vision based. Smoothing operation is used to make image look very clear by capturing certain pattern of data. Erosion operation is used to reduce the noise by deleting the spikes of data and reduces the size of data. Dilation operation is used to fill the empty void between pixels to make data look very clear.

VI. CONCLUSION

This project proposed the simplest fire detection algorithm which is free from ordinary fire detection systems which consists of number of sensors. The objectives of this project were to create a system which would be able to detect flame using images from feed, such as a video feed. The system was made to detect flame while they are still small and have not grown too large. To Develop a System, we select OpenCV library which are specially developed for image processing purpose and having high processing speed. So the system gives us promising results.

REFERENCE

[1]. X. Wu, C. Ngo, and Q. Li, "Threading and auto documenting news videos: A promising solution to rapidly browse news topics," IEEE Signal Process. Mag., vol. 3, no. 2, pp. 59–68, Mar. 2006.

[2]. Y. Wang, Z. Liu, and J. C. Huang, "Multimedia content analysis-using both audio and visual clues," IEEE Signal Process. Mag., vol. 17, no. 6, pp. 12–36, Nov. 2000.

[3]. MESH, Multimedia Semantic Syndication for Enhanced News Service, European Commission Project, IST 6th Framework Programme. Available: http://www.mesh-ip.eu/

[4]. KSPACE, Knowledge Space of Semantic Inference for Automatic Annotationand Retrieval of Multimedia Content, European Commission Project, IST 6th Framework Programme. Available: http://k-space.eu/

[5]. C. L. Lai, J. C. Yang, and Y. H. Chen, "A real time video processing based surveillance system for early fire and flood detection," in Proc.IEEE Instrum. Meas. Technol. Conf., Warsaw, Poland, May 2007,pp. 1–6.

[6]. P. Huang, J. Su, Z. Lu, and J. Pan, "A fire-alarming method based on video processing," in Proc. IEEE Int. Conf. Intell. Inform. Hiding Multimedia Signal Process., Dec. 2006, pp. 359–364.

[7]. T. Celik, H. Demirel, H. Ozkaramanli, and M. Uyguroglu, "Fire detection in video sequences using statistical color model," in Proc. IEEEInt. Conf. Acoust. Speech Signal Process., vol. 2. Toulouse, France, May2006, p. II.

[8]. P. V. K. Borges, J. Mayer, and E. Izquierdo, "Efficient visual fire detection applied for video retrieval," in Proc. 16th Eur. Signal Process.Conf., Aug. 2008.

[9]. B. U. Toreyin and A. E. Cetin, "Online detection of fire in video," inProc. IEEE Conf.

Comput. Vision Pattern Recognit., Jun. 2007, pp. 1–5.
[10]. C. Liu and N. Ahuja, "Vision-based fire detection," in Proc. Int. Conf.Pattern Recognit., vol. 4. Aug. 2004, pp. 134–137.
[11]. T. Celik, H. Ozkaramanli, and H. Demirel, "Fire pixel classification using fuzzy logic and statistical color model," in Proc. Int. Conf. Acoust.Speech Signal Process., vol. 1. Apr. 2007, pp. 1205–1208.
[12]. T. Chen, P. Wu, and Y. Chio, "An early fire-detection method based on image processing," in Proc. IEEE Int. Conf. Image Process., vol. 3. Oct.2004, pp. 1707–1710.
[13]. S. C. Liew, A. Lim, and L. K. Kwoh, "A stochastic model for active firedetection using the thermal bands of modis data," IEEE Geosci. RemoteSensing Lett., vol. 2, no. 3, pp. 337–341, Jul. 2005.
[14]. Y. Li, A. Vodacek, R. L. Kremens, A. Ononye, and C. Tang, "A hybrid contextual approach to wild land fire detection using multi spectral imagery," IEEE Trans. Geosci. Remote Sensing, vol. 43, no. 9, pp. 2115–2126, Sep. 2005.
[15]. A. Abuelgasim and R. Fraser, "Day and night-time active fire detection over North America using NOAA-16 AVHRR data," in Proc. IEEE Int.Geosci. Remote Sensing Symp., vol. 3. Jun. 2002, pp. 1489–1491.

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