Flame and Fire Monitoring Using Novel Algorithm of Edge Detection and Alert System Using GSM

M.G.Poorna Kala
Assistant professor,
Department of Electrical and Electronics Engineering,
Chandy college of Engineering,
Tamilnadu, India.
poornakala203@gmail.com

Abstract: -The fire hazards are one of the primary problems faced by the industries today. These fire hazards cause the loss of valuable lives and properties. Therefore it has become a major concern in the industries to control these fire hazards and proper solutions are to be developed to limit the fire accidents immediately so that casualties and the damages caused by the fire can be minimized. In this paper flame/fire area is determined using imageprocessing. Also the system sends an alert to the mobile user using GSM and to display it in order to avoid large-scale damage. This paper proposes the novel algorithm to determine the flame and fire edge from the given fire image and video. Edge detection of different flame images and videos are determined and compared with other techniques. The simulation result shows that this method is more effective than other edge detection techniques. Flame area is calculated for further process. Alert is generated when the area exceeds the threshold limit and the user receives a message for both normal and abnormal condition which is done using microcontroller.

Keywords—Edge detection, fire, flame, Flame image, Flame monitoring, Image Processing

I.INTRODUCTION

Edge detection is one of the important steps in flame image processing.Flame edge detection is important for several reasons. Flame edges determine the region of a flame. This is important in 3D reconstruction of the flame as without clearly defined edges, the flame cannot correctly be reconstructed. The use of flame edge can reduce the amount of processing data; filter out unwanted information, such as background noise within the image. It shortens the data processing time. The edge detection is used to segment a group of the flames. This is particularly important for the multiple flames monitoring where multiburner system is used [1].

Edge is the most significant part of local variation in images, and mainly appears between different objects, background, and different regions. It is the fundamental of image analysis for image segmentation, texture feature and shape feature extraction. Edge is very useful for image analysis and recognition, which can outline the objects' contours clearly. So finding proper edge detection method for flameimages is an indispensable step to ensure there liability and accuracy of extracting flame feature parameters. The shape of edges in images depends on many parameters: The geometrical and optical properties of the object, the illumination conditions, and the noise level in the images [2].

A novel method is proposed to detect flames in video by processing the data generated by an ordinary camera monitoring a scene[3].To meet the stringent standards on energy saving and pollutant emissions, advanced monitoring and characterization of flames have become highly desirable in the power generation industry[4].Despite many parameters are delicately adjusted in the use of these methods, flame edges still cannot be identified. It is therefore desirable to develop a dedicated edge detection method for flame image processing. As a result of recent work in characteristic analysis of flame images, a novel computing algorithm is proposed where some of the unique features of a flame image such as the number of main objects and strong comparative brightness are used to identify flame edges. Adopting these features, one can detect the coarse and superfluous edges in a flame image and then identify the flame main edges and remove the unrelated edges. To avoid from large-scale fire damage, many researches and studies are there about automatic real-time flame detection using image processing.Adaptive canny edge algorithm and flame geometric features are used to inspect the flame area of image captured by ccd or ordinary camera [10].

II. NOVEL ALGORITHM

Step1: Adjust the gray level of the image.

Step one is to adjust the gray scale of the flame image according to statistical distribution. Considering a discrete gray scale image *x* ,*n*ibe the number of occurrences of gray level of *i*, Probability of occurrence of a pixel of gray level i in the image

$$P_x(i) = p(x = i) = \frac{n_i}{n},\ 0 < i < L \quad (1)$$

Where*L* is the total number of gray levels in the image, *n*the total number of pixels in the image, *px*(*i*) the histogram for pixels with *i*, normalized to [0,1]. The cumulative distribution function (CDF) corresponding to *px*can be defined as,

$$CDF_x(i) = \sum_{j=0}^{i} P_x(j) \quad (2)$$

Next, create a transformation of form *y* = *T*(*x*) to produce a new image *{y}*, such that its CDF will be linearized across the value range with a constant number *K*, i.e.

$$CDF_y(i) = iK \quad (3)$$

To map values back to original range this following transformation is applied to the result.

$$y' = y * (\max\{x\} - \min\{x\}) + \min\{x\} \quad (4)$$

Step 2: Smoothing the image

Before identifying and detecting the edge the image is to be smootheningin order to filter the noise. Gaussian filter can be achieved using a simple mask. Gaussian smoothing is performed using standard convolutionmethods after a suitable mask are selected. The larger the width of the Gaussian mask, the lower the detector's sensitivity to the background noise in the flame/fire image, but a large mask may also detect the flame edge effectively.

$\frac{1}{115}$

2	4	5	4	2
4	9	12	9	4
5	12	15	12	5
4	9	12	9	4
2	4	5	4	2

Step3: Use the Sobel operator to find basic edges

By finding the gradients of all the pixels in the image basic edges is achieved inorder to highlight the regions with high gray level contrast at their edges. The algorithm then tracks the edge along these regions and suppresses any pixels that are not at the peaks of the gradients. If the magnitude of the gradient is above high threshold *TH*, it is deemed an edge. if the magnitude is between the two thresholds, i.e., the *TH* and *TL* (low threshold), it is set to zero unless there is a path from this pixel to a pixel with a gradient above the *TL*.

The Sobel operator performs a two dimensional spatial gradient measurement on an image. Then the approximate absolute gradient magnitude (edge strength) at each point can be found. It uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and another estimating the gradient in the y-direction (rows).It uses 3*3 convolution masks.

$$M_x = \begin{bmatrix} -1 & -2 & 1 \\ -2 & 0 & 2 \\ -1 & 2 & 1 \end{bmatrix} \quad (5)$$

$$M_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad (6)$$

$M_x$andM_y are the gradient in x direction (columns)and y direction(rows)

Step 4: Adjust TH and TL to get a better result

The "better" result is assessed by how many edges there are: The more edge pixels detected in the edge image, the better the parameters are. Another threshold *TE* is also set to restrict the total number of edges, i.e., if the number of edge pixels exceeds the *TE*, the automatic adjustment will be terminated. Until now, a preliminary image with edges identified is obtained from the original flame image. It is designated as a preliminary edge image (PEI). Fig1 shows the complete flowchart of the novel algorithm.

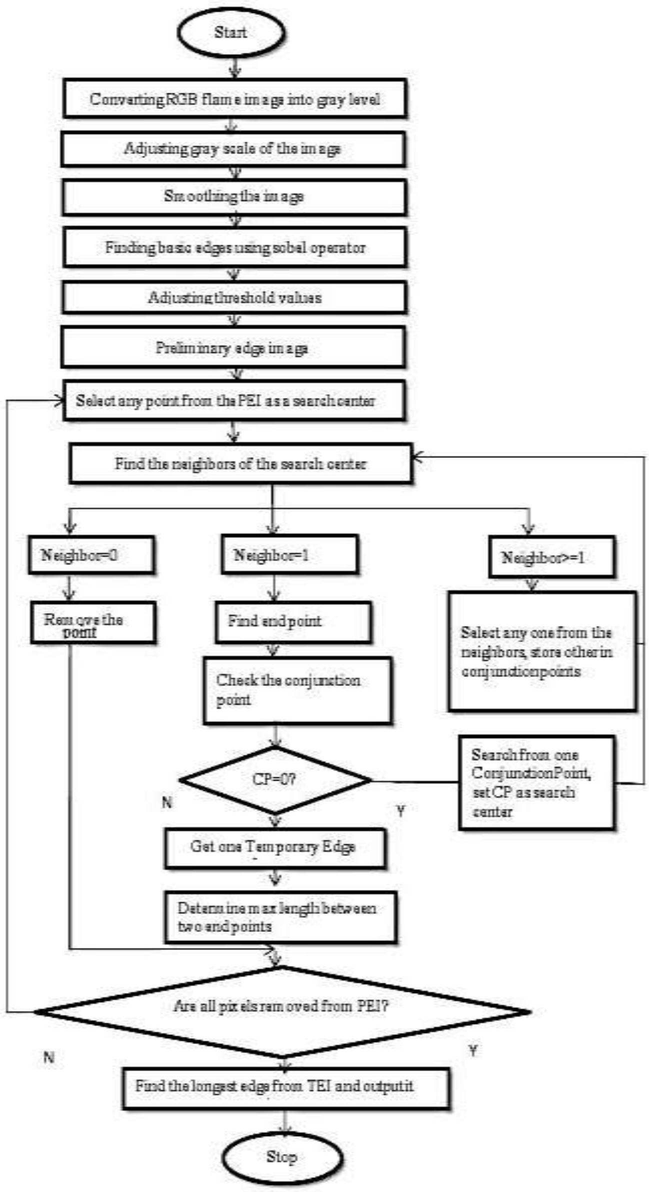

Fig 1: Complete flow chart of novel algorithm

Step 5: Remove unrelated edges in the PEI through the following steps;

5a) Select any edge point in the PEI, remove that point from the PEI, allocate a new temporary edge image and plot the point onto the temporary edge image.

5b) Use the selected point as the center and search in a 3×3 area. Store the location of all the neighboring pixels if they are edge pixels.

In eight neighboring pixels, operations are taken for the following three different cases,

-If there is no neighboring pixel, the selected point is then an isolated point, and should be removed from the PEI. Terminate the search and go to Step 5d.

- If there is one neighboring pixel, the selected point is an end point. It should then be removed from the PEI, plotted onto the temporary edge image, and added into the endpoint list. Start the new search from the found neighbor and go to Step 5c.

- If there are more than two neighboring pixels, then the selected point is a normal transition point in an edge line or an intersection with more than three bifurcations. Set one of the neighboring points as the new search center and start a search. Store the other positions as unchecked conjunction points, and then go to Step 5b

5c) Check the conjunction points (CP). If all the conjunction points have been searched as a center, one temporary edge image is then completed. Compute the lengths of any two end points in the temporary edge image and pick out the longest one. Then go to Step 5d.

5d)If all the pixels in the PEI are moved to the temporary edge image, then go to Step 6.

Step 6: Plot the pixels of the longest edge in the final edge image which should have the same size as the original image. The whole process is then complete.

III.SIMULATION RESULT

The simulation was done using MATLAB and the fig 1 shows the clear and continuous edge detected from the flame image.

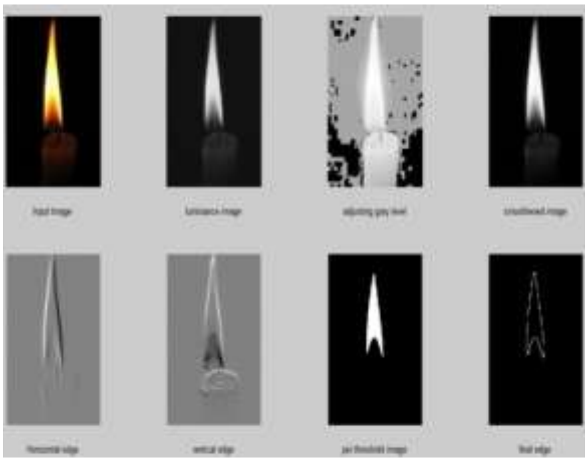

Fig.2: Stepwise simulation output for the flame image using the proposed edge detection algorithm

Initially the flame image was converted to gray scale image. Next smoothening process was done to filter the noise. It gives blurred image. After implementing the proposed algorithm, the edge of the flame image was obtained. Fig 2 shows the various fire and flame image and its edge.Fig.3 shows the image with added salt and pepper noise and finally the edge was detected..

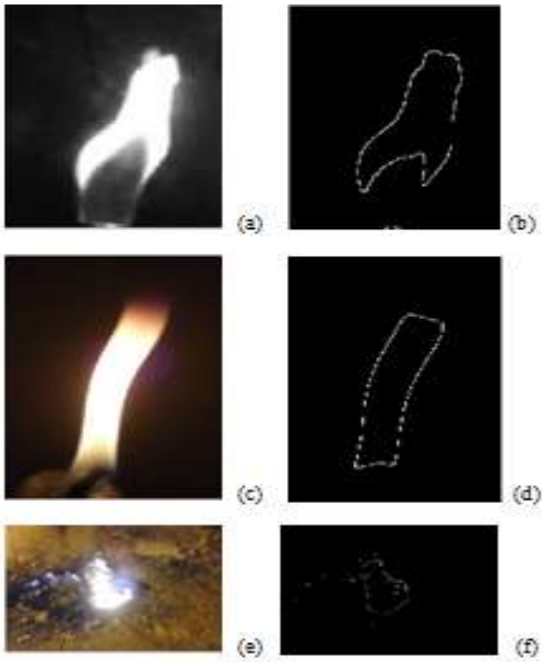

Fig (3): Some of the edge detection results (Left column): Originalimages (Right column): Images with Identified edge.

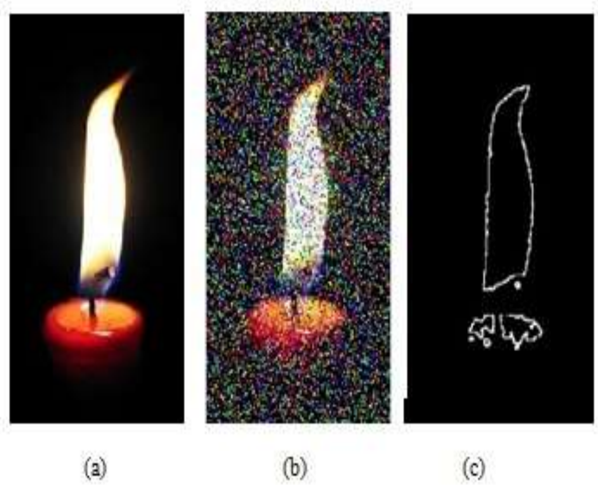

Fig4 (a); Original image; 4(b): Original image with added Salt and pepper noisy; 4(c): Final edge

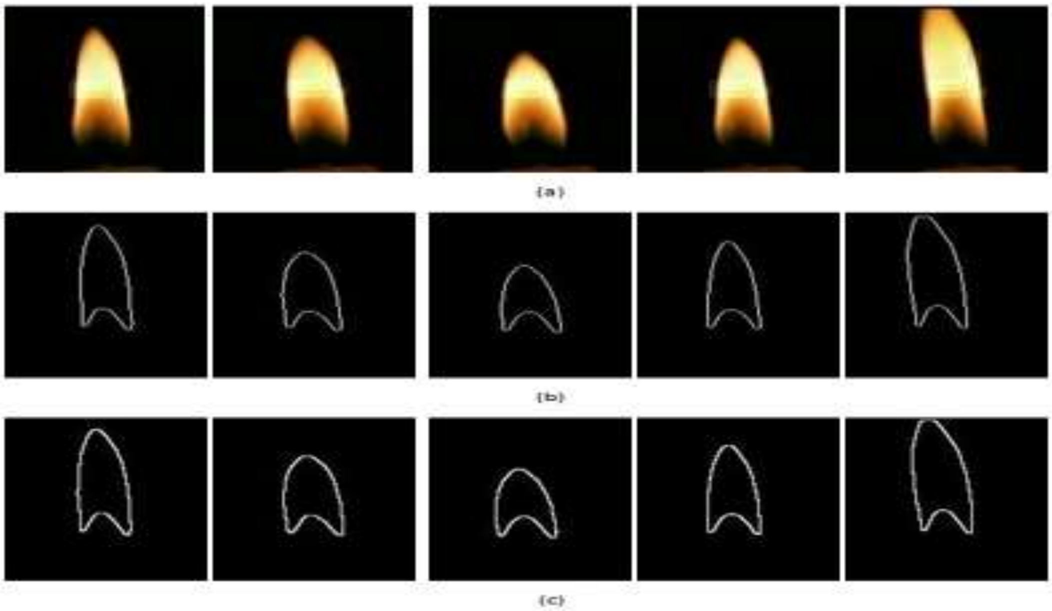

Fig 5. Edge-detection result for a flame video(a) Frames in a flame video. (b) Detected flame edge from the video sequence using the Canny edge-detection method.(c)Detected flame edge from the video sequence using the proposed method.

Fig. 5(a) shows a series of frames acquired from a flame video. Fig. 5(b) and 5(c) shows the edge-detection results using both the Canny edge-detection method and the proposed algorithm. It is clear that the flame edges detected using the Canny edge-detection method are unclear and discontinuous, while the results obtained using the proposed algorithm show clear and continuous edges with parameters automatically adapted.The clearly defined flame edges will form a basis for subsequent processing of the flame images, for example, flame size computation, flame background removal, and determination of other flame parameters. The area of the flame edge is also calculated and from which further experiments can be done.

IV. HARDWARE IMPLEMENTATION

The block diagram shown in fig 6 which consists of PC, Atmega microcontroller, GSM modem, Alarm and driver circuit. The hardware description of the project is discussed below.

While implementing in hardware, the input flame image is given. It is programmed in such a way that if area of the image exceeds threshold limit the fire is in abnormal condition else normal condition. In case of abnormal condition alert is given to mobile user using GSM and buzzer beeps. For normal case, message is sent to the mobile. First entered cell number is saved automatically. New number can be entered if the old number has to be changed. Laptop is interfaced with hardware using serial to USB connector. Software tool consists of two parts: Matlab tool for simulation in order to find the area of the flame, On the other hand embedded c is used to control the flame also for monitoring.

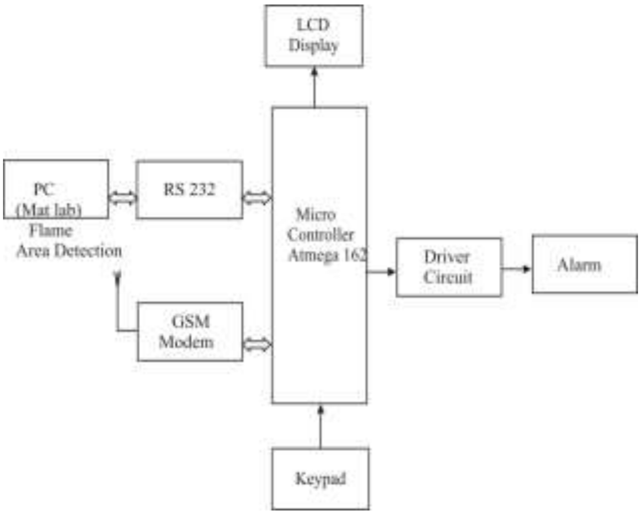

Fig.6: Block diagram of flame monitoring system

V. HARDWARE RESULT

When the matlab program is made to run, it asks for select image. Any flame/fire image is given as input. Then by using proposed novel edge detection algorithm, flame edge is detected and finally flame area is determined. The data is then sent to microcontroller through serial communication. Control is made for two cases: Fire in normal condition and Fire in abnormal condition.

FIRE IN NORMAL CONDITION

When the flame area is within the given threshold limit, it is considered as normal. LCD displays as ―FIRE-NORMAL and message is sent to mobile as ―FIRE IN NORMAL CONDITION. The figure 7.1 shows the input for normal condition and figure 7.2 shows the result for fire in normal condition.

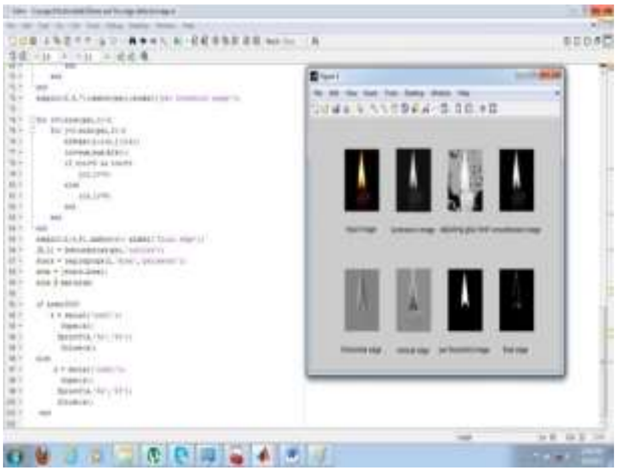

Fig 7.1:Input image for normal condition

Fig 7.2:Hardware result for normal condition

FIRE IN ABNORMAL CONDITION

When the flame area is beyond the given threshold limit,it is considered as abnormal. LCD displays as ―FIRE ABNORMAL and message is sent to mobile as ―FIRE IN ABNORMAL CONDITION. Also the alarm sounds. The figure 8.1shows the input for abnormal condition and figure 8.2shows the result for fire in abnormal condition.

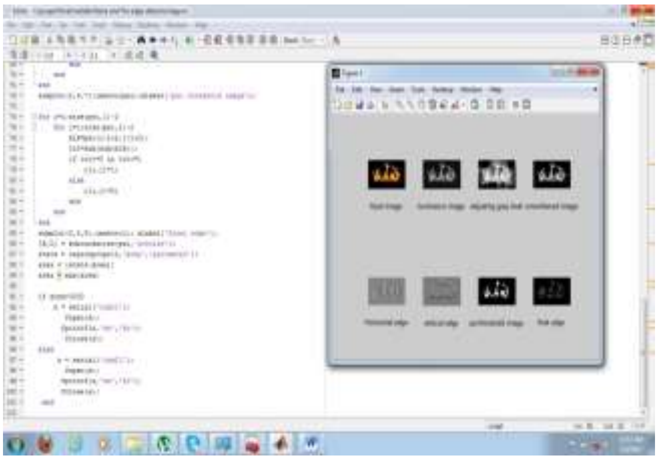

Figure 8.1 Input image for abnormal condition

Figure 8.2: Hardware result for abnormal condition

VI.CONCLUSION

By implementing the algorithm described in section II the flame image and video were processed and the edge was detected for the image and video. Experiment result with effective flame edge was detected. Then the image was tested by adding salt and pepper noise and the output was effective with clear and continuous edges. Proposed method gives clear and continuous flame edge for the flame video. The flame area was determined for any flame/fire from which future works can be done. Several parameters like Flame surface area, Flame shape, Flame spread speed, can be calculated. Thus the experimental result has demonstrated that the algorithm was effective for noisy image withirregular flame and finally effective edge detection algorithm was developed. In this proposed methodology, a fire alert system is developed for fire monitoring. The simulation with hardware implementation for fire monitoring has been done. It is checked by receiving fire alert messages and by the beep sound. The experimental result has demonstrated that the algorithm was effective for noisy image with irregular flame and finally effective edge detection algorithm was developed. Several parameters like Flame surface area, Flame shape, Flame spread speed, can be calculated. It is applicable in fire based industries, thermal power plants, laboratories etc. The simulation with real time application has to be developed in faster speed. This may reduce the risks of human in case of large fire hazards.

VII.REFERENCES

[1] TianQiu, Yong Yan and Gang Lu"An Auto adaptive Edge-Detection Algorithm for Flame and Fire Image Processing" *IEEE Trans. Instrum. Meas*., vol. 61, no. 5, may 2012

[2]H.Chidiac, D.Ziou, "Classification of Image Edges", Vision Interface'99, Troise-Rivieres, Canada, 1999.pp. 17-24.

[3] B. U. Toreyin, Y. Dedeoglu, and A. E. Cetin."Flame detection in video using hidden markov models."In *ICIP '05*, pages 1230–1233, 2005.

[4] G. Lu, Y. Yan, and M. Colechin, "A digital imaging based multifunctional flame monitoring system", IEEE Trans. Instrum. Meas., Vol. 53, No. 4, pp. 1152-1158, 2004

[5] Y. Yan, T. Qiu, G. Lu, M. M. Hossain and G. Gilabertet, "Recent advances in 3D flame tomography", Proceedings of the 6th World Congress on Industrial Process Tomography, Beijing, China, pp. 1530- 1539, September, 2010.

[6] D. S. Huang, L. Heutte, and M. Loog, "Real-time fire detection using camera sequence image in tunnel environment", ICIC 2007, LNCS 4681, pp. 1209–1220, 2007.

[7] G. Lu, G. Gilabert and Y. Yan, "Vision based monitoring and characterisation of combustion flames", Journal of Physics: Conference Series 15, pp. 194–200, 2005.

[8] H. C. Bheemul, G. Lu, and Y. Yan, "Three-dimensional visualization and quantitative characterization of gaseous flames," Meas. Sci. Technol., vol. 13, No. 10, pp. 1643–1650, 2002.

[9] B. C. Ko, K. H. Cheong, and J. Y. Nam, "Fire detection based on vision sensor and support vector machines ", Fire Safety Journal, Vol. 44, pp. 322–329, 2009.

[10] Q. Jiang, and Q. Wang, "Large space fire image processing of improving canny edge detector based on adaptive smoothing", 2010 International Conference on Innovative Computing and Communication and 2010 Asia-Pacific Conference on Information Technology and Ocean Engineering, 2010.

[11] R. C. Gonzalez and R. EWoods, Digital Image Processing, Second Edition, Prentice Hall, 2002.

[12]T. Qiu, Y. Yan, and G. Lu, "A medial axis extraction algorithm for combustion flames through digital image processing," in *Proc. 6th ICIG*, Hefei,China, Aug. 12–15, 2011, pp. 182–186.

[13] T. Steinhaus, S. Welch, R. Carvel, and J. L. Torero, “Large-scale pool fires”, Thermal Science Journal, Vol. 11, No. 3, special on fire, 2007.

[14] J. Canny, “A computational approach to edge detection”, IEEE Transactions on PAMI, Vol. 8, No. 6, pp. 679 698, 1986.

[15] K. R. Castleman, Digital Image Processing, Prentice Hall, 1995

[16] SWRI, “Small-scale liquid pool fire characterization”, Available at:
http://www.swri.org/4org/d01/fire/firetech/about.htm.

[17] Zhang Jinhua, ZhuangJian, and Du Haifeng, “A Flame Detection Algorithm Based on Video Multi-feature Fusion”, *Lecture Notes in Computer Science*, Vol.4222, pp.784-792, 2006.

[18] S. Osher, J. A. Sethian, “Fronts Propagating with Curvature dependent Speed: Algorithms Based on Hamilton-Jacobi Formulations”, *Journal of Computational Physics*, Vo1.79, No.1, pp.1-31, 1988.

[19] T. F. Chan, L. A. Vese, “Active Contours Without Edges”,*IEEE Transactions on Image Processing*, Vo1.10, No.1, pp.266- 277, 2001.

[20] Wang Dakai, Houyuqing, and PengJinye, *Partial differential equations method of Image processing*, Science Press, Beijing, 2008. (In Chinese)

[21] Zhang Hanling, *Matlab in Image Processing, Tsinghua University Press*, Beijing, 2008. (In Chinese)

[22] N. Oza and S. Russell. Online bagging and boosting. In *Artifical Intelligence and Statistics*, pages 105–112, 2001.

[23] F. T. SA. *Method and Device for Detecting Fires Based on Image Analysis*. PCT Pubn.No: WO02/069292, Boulevardde Grancy 19A, CH-1006 Lausanne, Switzerland, 2002.

[24] B. U. Toreyin, Y. Dedeoglu, and A. E. Cetin. Wavelet based real-time smoke detection in video. In 13*th European SignalProcessing Conference EUSIPCO*, 2005.

[25] B. U. Toreyin, Y. Dedeoglu, U. Gudukbay, and A. E. Cetin. Computer vision based system for real-time fire and flame detection. *Pattern Recognition Letters*, 27:49–58, 2006.

[26] J. Vicente and P. Guillemant.An image processing technique for automatically detecting forest fire.*International Journalof Thermal Sciences*, 41:1113–1120.