색상과 움직임 정보 기반의 화재 감지 알고리즘

Fire Detection Algorithm based on Color and Motion Information

알라 킴*, 김윤호**

Alla Kim*, Yoon-Ho Kim**

요 약

본 논문에서는 공공장소에 광범위하게 설치되어있는 CCTV의 감시 기능을 활용하여 화재 발생 감지 방법을 제안하였다. 제안한 방법은 고정된 카메라로부터 칼라 정보를 이용하여 비디오 시퀀스의 화재 프레임 후보를 찾아내고, 공간 기법을 기반으로 감지된 화재 정보의 전경 색상을 분석하였다. 실험 결과, 비디오 시퀀스에서 시·공간적 화재 후보 정보들이 급격히 변화할 때, 화재 감지의 성능이 우수함을 확인할 수 있었다.

Abstract

In this paper, we propose the method of fire detection. A wide distribution of CCTV cameras (Closed Circuit Television) in many public areas can be used not only for video surveillance systems but also for detecting fire occurrence. A proposed approach is based on visual information through a static camera. Video sequences are analyzed to find fire candidates and then spatial analyses procedure for detected fire-like color foreground is carried out. From the simulation results, our method showed the best performance when spatial and temporal fire candidates changes rapidly and close to fire motion.

Key words : fire detection, flame detection, color detection

I. 서 론

Fire detection conventional smoke and fire detectors are widely used, but they are fail to maintain open and large spaces. The advantage of visual fire detection systems is that they can be used in cases when above mentioned detectors are not reliable, in addition visual systems can use cameras to obtain video data for further processing. An approach that is proposed in this paper based on several steps. In a pre-processing stage raw input video is changed in a form that can be used and conformed to an algorithm's goal and capability of acquisition device. A pre-processing step is followed by background subtraction procedure in order to detect motion (changes in a video sequences). Background modeling was constructed by using Approximated Median Filter (AMF) [1]-[3]. Background/Foreground detection plays a distinctive role in visual based analysis systems. In this step motion is detected and background (or statical) pixels are removed. The procedure is a foundation for many visual systems. Lately a lot of different approaches have been proposed and developed,

ability to separate background and new foreground object is a crucial point for further pro-processing steps.

Color verification process classifies detected foreground pixels as fire in case if they match color detection procedure and remove all foregrounds that don't. Pixels that are detected by algorithm are considered as fire candidates. We form blobs and check their spatial characteristics and apply to noise suppression technique to remove some fire-like pixels caused by illumination changes[4]. Then all blobs go through spatial analysis in order to take final decision whether it is a fire and system should make a notification or it is a fire-like object. The organization of the paper is as follows: in section Ⅱ a description of research is given. In section Ⅲ, results of approach are presented. Finally section Ⅳ is devoted to conclusion.

Ⅱ. Proposed fire detection method in a video sequence

An overall description of fire-detection algorithm is given in Fig. 1. In order to identify changes that can be resulted by fire we used motion detection procedure from previous paper[1]. Then detected pixels went through a color (detection) classification procedure. Background modelling (also referred too as background subtraction) was based on Approximated Median filter (AMF). AMF had been previously used for classification system and urban traffic monitoring [5][6].

AMF based B/F (Background/Foreground) detection maintains a background model and background subtraction procedure separates foreground and background. If a pixel value in the current frame has a value larger than the corresponding background pixel, the background pixel is incremented by 1. Otherwise the background is decremented by one. In this way input data comes to a state when half of pixels are greater then the background and half are less than the background.
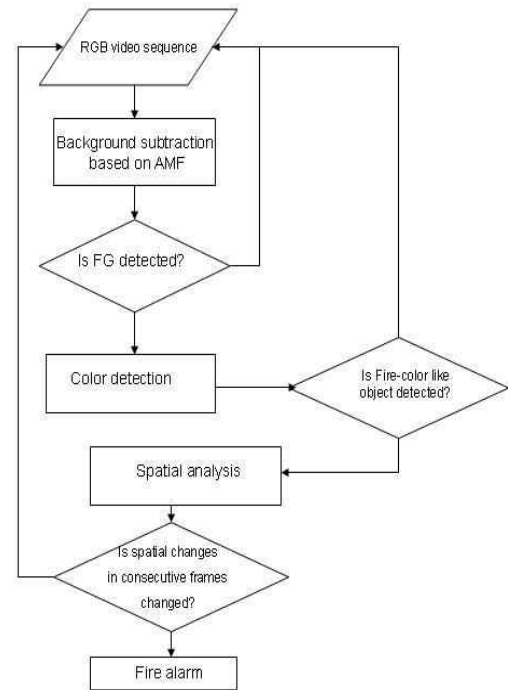

Fig. 1. A fire detection flow-chart

Foreground pixel are detected by calculating the Euclidean norm at time t:

$$\| I_t(x,y) - B_t(x,y) \| > T_e \qquad (1)$$

where I_t is the pixel intensity value, B_t is the background intensity value at time t and T_e is the foreground threshold.

$$I_t = [I_{1,t}...I_{c,t}]^T \qquad (2)$$
$$B_t = [B_{1,t}...B_{c,t}]^T$$

where c is the number of image channels[6].

The foreground threshold T_e determined experimentally. We used different thresholds for different video sequences, remember that threshold should be adjusted with respect to the complexity of the scene and depends on dynamics of the environment. The parameter is adaptive, if the object movements are fast, then T_e can be kept small, otherwise T_e should be kept large [7]. For ignited New Year tree we intentionally used $T_e = 20$, for human motion in-doors

sequence $T_e = 6$, for pen motion (we just waved a red pen in front of camera) $T_e = 20$.

For color detection procedure we used next classification [8]:

1) First we try to define pixels whose value in a Red channel is greater then mean of pixels of Red channel.

$$R_t(x,y) > R_{mean} \tag{3}$$

Where R(x,y) is the pixel intensity value at time t in spatial location of (x,y). R_{mean} is the mean of

Red channel pixels intensity values.

$$R_{mean} = \frac{1}{N} \sum_{i=1}^{N} R(x_i, y_i) \tag{4}$$

where N is a total number of pixels in frame.

2) Pixels in a Red channel suppose to be greater then pixels values of Green channel and those ones suppose to be greater then Blue channel's ones.

$$R_{(x,y)} > G_{(x,y)} > B_{(x,y)} \tag{5}$$

where R(x,y), G(x,y), B(x,y) are Red, Green and Blue channel values at spatial location of (x,y). If colors of foreground pixels match to the fire color, we carried out spatial analyses procedure. Spatial analysis is used in order to enhance algorithm output. There are many things that share the same color as fire that's why color alone is not enough sufficient for fire identifying the key solution here to use spatial temporal variations[4].

In further step color is not important anymore so we obtained binary blobs and analyzed their area and spatial mean [9]. If blob's area (connected components) is less then 10 pixel we suppose that it is a noise and remove it. An assumption that flame (fire) has temporally spatial changes in area can be used so if blob's area doesn't change through video sequence it is considered as non-fire object (ex. sun, red roof, red clothes on a human and soon), otherwise a notification is generated by system [10][11].

Ⅲ. Experimental Results

Fire detection was conducted by using Matlab Image Acquisition toolbox, test was performed on Intel Processor 2.83 HGz, 1.98 Gb of RAM. We acquired RGB video sequence with an ignited New Year tree in-doors, human motion in-doors and red pen motion. Video was adjusted in a form appropriated for conducting experiment on Matlab (transformed to avi format).

Changes that were detected by background and foreground detection procedure were represented in column 1, Fig. 1. Background scene modelling was implemented by using approximated median filter, though the AMF has a good performance it adapts very slowly to large changes in background and is sensitive to environmental noise.
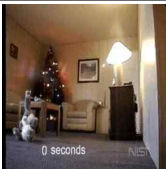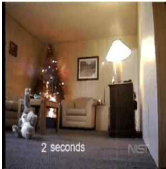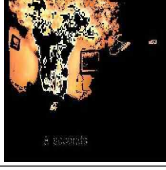

Fig. 1. Experimental result

Since the amount of background update (+1 or -1) is independent of the foreground pixels, it is very robust against moving traffic. The only drawback is that it adapts slowly toward a large change in background [12]. For example, as shown in frames that includes a quick or abrupt explosion (frame#45, frame#51) of fire were failed to define background and foreground, except regions that contain furniture and other static objects, but color-like object was defined and segmented by color classification procedure. Low frame rate can also improve the result. Additional sophistications can be implemented to enhance algorithm's output. All others motion segmentation details are described in a section Ⅱ and Ⅲ [1].

Color classification procedure was maintained as formulated in (3), (4) and (5) and was tested in still images (Fig.2) and video sequences (Fig. 1). Bounding box was constructed and covered every fire colored blob.

Fig. 2. Color procedure in still images

Unfortunately, on a video with a tree, bright regions in the center of flame wasn't defined, cause their color is more close to white then red and doesn't match color classification rules. Commonly for background subtraction algorithm and color classifier as well, binary

mask is used in order to mark all matched components. However color information is extremely important for visual color detection system, it is commonly advised to use some noise suppress on this stage, but noise suppression was performed after applying color classification and removing all non-fire colored objects (Fig. 1, column 3). For noise suppression and spatial analysis binary changes map was obtained by converting all defined objects into binary representation.

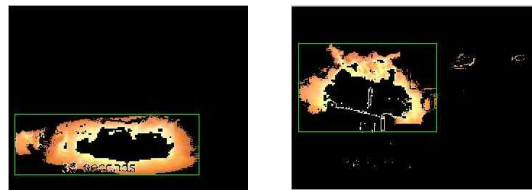Fig. 3. Fire-colored blob covered by bounding box

All isolated pixel (individual 1's that are surrounded by 0's) were removed. Then all connected components (objects) that have fewer than 10 pixels were removed from a binary image (Fig.3).

Fig. 4. frame #38
a)original image, b) binary changes map, c) after noise removing
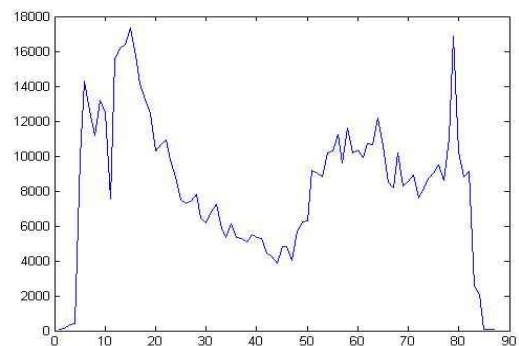

Fig. 5. Ignited New Year tree
(x-axis: frame, y-axis: object's area)

Then spatial and temporal analysing was done. Because many objects can have fire-like color, color detection procedure can give many false positives in case of red car, sun or others. Implementing spatial changes in area can be used to confirm that object is fire. If blob's area doesn't change through video sequence it is considered as non-fire object (ex. sun, red roof, red clothes on a human and soon), otherwise a notification is generated by system.

On video sequences with ignited tree, object's area changed significantly versus time. This spatial variation happens because of fire nature. Fire is tending to change its area during the swinging (Fig.5). On video sequences with red pen, changes doesn't occurs much throughout the course of the sequences (Fig.6).
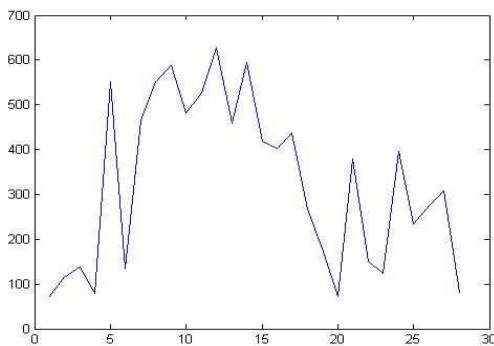

Fig. 6 Red pencil motion
(x-axis: frame, y-axis: object's area)

Table 1. Results for sequences tested

Sequence	TP	FP	FN	Experimental Model
1	87	0	4	Ignited New Year tree
2	0	4	0	Pen's motion
3	0	0	0	Human motion in-doors

- TP: True positive, FP: false positive, FN: false negative

On last sample video (human motion in-doors) color segmentation procedure didn't detected any fire colored regions (human was dressed in dark T-shirt and shorts), so area analysing wasn't performed.

In order to have a quantitative evaluation of the performance, we applied our approach on sampled video sequences. Then detected fire frames were counted. If the algorithm counts a frame with no fire, we consider that an error (false positive) occurs, in case when there is a fire on frame, but it was missed we consider that it is false negative.

IV. Conclusion

In this paper, we have developed a fire detection method in RGB video sequences. Proposed approach includes different techniques to obtain object and define whether it is a fire candidate or not. Objects detection was based on background subtraction procedure. After motion pixels had been defined color classification was implemented, all fire-like pixels where checked on possible spatial variation. If pixel intensity changes fast and spatial changes are high, fire is detected, otherwise it is considered as fire-like object.

References

[1] Alla Kim, Yoon-Ho Kim, "RGB Motion segmentation using Background subtraction based on AMF", 2009

[2] N.McFarlane and C. Shofield, "Segmentation and tracking of piglets in images", *Machine Vision and Applications, Springer,* Vol. 8, no.3, 1995.

[3] Seth Benton, "Background subtraction, Matlab Models", 2008.

[4] Water Philips III, Mubarak Shah, Niels da Vitoria Lobo, Flame recognition in video, Pattern Recognition Letters 23 (2002) 319-327.

[5] Swantje Johnsen and Ashkey Tews, "Real-Time Object Tracking and Classification Using a Static Camera", *Proceedings of the IEEE ICRA 2009,* Workshop on People Detection and Tracking, Kobe, Japan, May, 2009.

[6] P.Remagnino et al., "An integrated traffic and pedestrian model-based vision system", *Proceedings of BMVC97, Vol. 2, Colchester, 8-11 th September, University of Essex,* UK, pp380-389, 1997.

[7] Turgay Celik, Hasan Demirel, Huseyin Ozkara-manli, Mustafa Uyguroglu "Fire detection using statistical color model in video sequences", *Advanced Technologies Research and Development Institute, Eastern Mediterranean University,* Gazimagusa TRNC, Mersin 10, Turkey, 2005.

[8] Thanarat Horprasert, David Harwood, Larry S. Davis, "A statistical approach for real-time robust background subtraction and shadow detection", 1999.

[9] Alexandre R. J. Francois and Gerard G. Medioni, "Adaptive color background modeling for real-time segmentation of video streams", *Proceedings of the Int'l on Imaging Science, Systems, and Technology,* pp. 227-232, Las Vegas, Nevada, June 1999.

[10] Behzcet Ugur Toreyin, "Fire detection algorithms using multimodal signal and image analysis", 2009.

[11] Rastislav Lukac, Konstantinos N. Plataniotis, "Color image processing: methods and applications", *Published by CRC Press, ISBN 084939774X, 9780849397745,* 2006.

[12] Sen-Ching S. Cheung and Chandrika Kamath "Robust techniques for background subtraction in urban"

Alla Kim

received B. S. degree in economics and management field in Tashkent Univ. of Information Technologies in 2008, Uzbekistan. Now Master degree student in Mokwon Univ., dept. of IT engineering. Focusd on Image Processing and Computer Vision.

Yoon-Ho Kim

received the B.S. degree in electronic engineering from Chong-Ju Univ. and M.S. degree in electronic engineering from Kyung-Hee Univ. in 1986, and the ph.D. degree in electronic engineering in 1992 from Chong-Ju Univ., respectively. In 1992, he joined the faculty member of the Mokwon Univ.. He is currently a professor in the Dept. of Computer Engineering, Mokwon Univ.. From 2005 to 2006, he was with Univ. of Auckland, where he served as a research fellow. Since in 2008, he has been working as a Korea Delegate in ISO/TC223. His research interests focus on image processing, including pattern recognition, computer vision, fuzzy technologies. He is a member of the IEEE, and IEEE Computer Society, IEEK, KICS and KIIT.