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FIRE DETECTION USING SURVEILLANCE SYSTEMS

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ABSTRACT

This research aims at presenting a video-based system to detect fire in real time taking advantage of already existing surveillance systems for fire detection either inside or outside the building with different illumination and short or long distance surveillance scenes. Detection of fires with surveillance cameras is characterized by early detection and rapid performance. Information about the progress of the fire can be obtained through live video. Also vision-based system is capable of providing forensic evidence. The basic idea of the research is fire detection based on video as proposed Fourier descriptors were used to describe reddish moving objects. The proposed system idea is to detect reddish moving bodies in every frame and correlate the detections with the same reddish bodiest over time. Multi-threshold segmentation is used to divide the image. This method can be integrated with pretreatment and post-processing. The threshold is one of the most common ways to divide the image. The next stage after the segmentation is to obtain the reddish body features. The feature is created by obtaining the contour of the reddish body and estimating its normalized Fourier descriptors. If the reddish body contour's Fourier descriptors vary from frame to frame, one can predict fire.

Index words: Tracking moving objects, Object segmentation, Fourier descriptors.

I. INTRODUCTION

The traditional method of detecting fires suffers from many disadvantages for several reasons. The first reason is that fires are not detected unless smoke is detected, and it is difficult to detect fires early if there is not enough smoke. Secondly, at the beginning of fires, if smoke is not emitted or is delayed, some areas surrounding the fire may be burned, causing many damages. Thirdly, smoke detectors take a long time to detect smoke, which causes many losses until precautionary measures are taken. Most alarms work in closed environments and are not effective for large areas such as outdoor areas or public places, so the need for advanced monitoring systems that detect fires has become a necessity.

II. RELATED WORK

Khan et al. proposed a video-based method [1] using the dynamics of the flame and detecting static internal flame using flame color and area. Color segmentation is performed to separate probable fire regions using the red component in RGB. Moving pixels are selected using frame differences from the previous frame followed by noise removal. In the next stage, the growth of segmented areas of the current frame is compared with subsequent frames and because risk expands over time, the areas that have no growth are removed. Therefore, this method faces a problem in identifying fires as they begin. Seebamrungsat et al. [2] proposed a system that uses hue saturation intensity value color model HSV and ycbcr color model to detect fire. Their system depends on static features of the flame, which may lead to false alarms. Chen and Huang [3] proposed a model that integrates motion, color, and spatial information to identify areas of fire in video frames. They model the fire color by using Gaussian mixture model to detect the fire region. The disadvantage of this method is that Guassian mixture model requires higher arithmetic operations. Burnett and Wing [4] Use cameras with low cost that can decrease the overlap between smoke and flames and have the ability to detect HSV and RGB. However, the application is still limited and there are some restrictions.

III. AN OVERVIEW OF THE PROPOSED SYSTEM

The fire detection process passes through several stages as shown in Fig. 1.

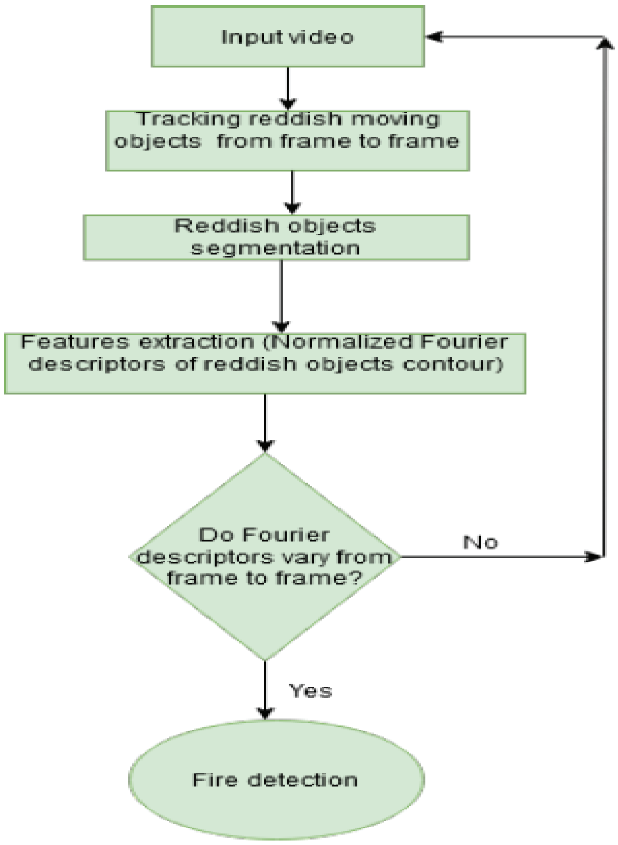

Fig. 1. The stages of the proposed fire detection system (i) Tracking reddish moving bodies (ii) The segmentation of reddish bodies, and (iii) The extraction of the feature.

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The first phase of the proposed system is the detection and tracking of moving reddish objects over time from frame to frame using point analysis to discover connected groups of pixels that match the reddish moving objects. Figure 2 shows samples of fire detection indoor, Figure 3 shows samples of fire detection outside the building, Figure 4 shows a sample of Forest fire detection and Figures 5 and 6 show fixed shapes of reddish objects. The proposed system's second phase is the segmentation of the reddish object; the multi-threshold segmentation method is used to segment the reddish objects in each frame followed by the use of Canny edge detection. In the scene, the system identifies two things the first is the Center of gravity (COG) and the second is the bounding box of each reddish object. Feature extraction is the third phase of the system. The system eliminates the influence of starting point variation by determining the position of each point on the reddish object's circumference according to the center of gravity. Fourier descriptors are then calculated for each point on the perimeter of the segmented reddish object with removal of scale and effects of rotation anisotropy. This is done by obtaining the normalization of the Fourier descriptors and it can also be obtained by dividing the absolute value of Fourier descriptors by their maximum absolute value. The system plots the Fourier scale descriptors of each contour of a reddish object traced in each frame and divides it into equal periods between [0,1] step 0.1 and takes it as 10 × 1 feature vector. The system compares the feature vector of each traced reddish object in the scene from frame to frame and in the case of variation the system detects fire and sends the alarm.

Fig. 2. Samples of fire detection indoors.

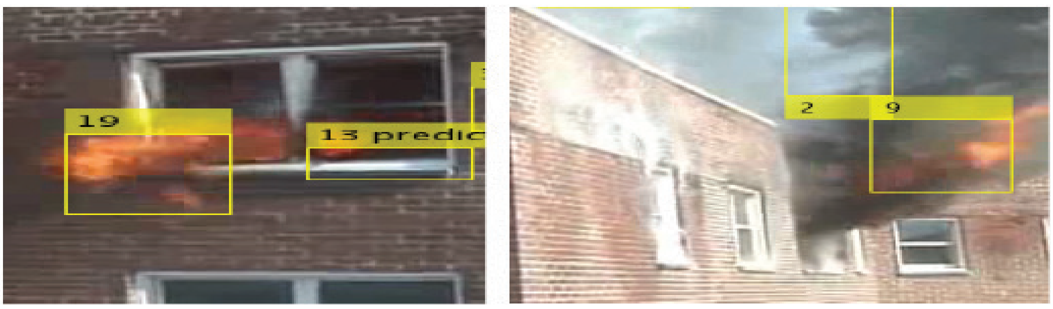

Fig. 3. Samples of fire detection outside the building.

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Fig. 4. Sample of Forest fire detection.

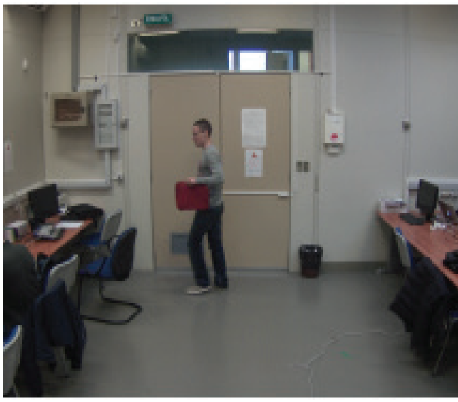

Fig.5. A person holding a red ball.

Fig 6. Sunlight appears from a distance as it travels in straight lines.

A. THE EXTRACTION OF THE FEATURE

1-Fourier Descriptors (FD)

Fourier Descriptors [5] can be used to represent closed two-dimensional shapes. The point that moves along the border generates a complex function:

$$Z(m) = x(m) + jy(m). \quad (1)$$

Fourier Descriptor is defined as

$$Z(k) = \frac{1}{N}\sum_{m=0}^{N-1} Z(m) \quad (k=0,\ldots\ldots\ldots,N-1) \quad (2)$$

If S is the shape scaling factor, then

$$\dot{Z}(m) = SZ(m), \quad (3)$$

If θ is the angle through which the shape rotates, then

$$\dot{Z}(m) = Z(m)e^{j\theta} \quad (4)$$

and if the starting point is moved, then

$$\dot{Z}(m) = Z(m - m_{\circ}) \quad (5)$$

$$\dot{Z}(m) = SRZ(m) + T \quad (6)$$

S: Scale ($R = e^{j\theta}$): Rotation T: Translation

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$$\dot{Z}(k) = \frac{1}{N}\sum_{m=0}^{N-1}\left[SRZ(m) + T\right]e^{\frac{-j2\pi mk}{N}} \quad (7)$$

$$\dot{Z}(k) = \frac{1}{N}\sum_{m=0}^{N-1}SRZ(m)e^{\frac{-j2\pi mk}{N}} + \frac{1}{N}\sum_{m=0}^{N-1}Te^{\frac{-j2\pi mk}{N}} \quad (8)$$

II. EXPERIMENTS

The researcher tested the algorithm on a data set containing 14 videos, three of which do not contain fires, some outside the building and some inside the building. The dataset consists of 5686 frames acquired in both outdoor and indoor situations. Table I contains information about the videos such as resolution, Frame rate, and the number of frames in each video. The system was able to differentiate between the light of cars, sunlight, and fires, as the light travels in straight lines. The constant shape of the reddish objects in videos that do not contain fires enabled the system to avoid false positives. The system is also capable of detecting small fires; thus, it is considered superior to smoke-sensing systems. However, the proposed system is not suitable for detecting large fires whose boundaries are outside the range of surveillance cameras, In this case, the researcher suggests using convolutional neural networks (CNN) but Taking into account that the implementation of convolutional neural networks based fire detection systems in real-world surveillance systems requires high memory and computational power.

TABLE I
THE EXPREMENTAL DATASET

Video sequences	Resolution	Frame rate	Frames	Fire
Video 1	480×272	29 frames/sec	140	yes
Video 2	480×272	29 frames/sec	1655	yes
Video 3	640×424	29 frames/sec	377	yes
Video 4	400×256	29 frame/sec	29	yes
Video 5	800×600	15 frame/sec	1485	No
Video 6	256×144	24 frame/sec	240	yes
Video 7	256×144	24 frame/sec	480	yes
Video 8	800×600	15 frame/sec	1485	No
Video 9	400×256	15 frame/sec	240	yes
Video 10	400×256	15 frame/sec	240	yes
Video 11	400×256	15 frame/sec	210	yes
Video 12	400×256	15 frame/sec	210	yes
Video 13	352×288	10 frame/sec	140	yes
Video14	320×240	15 frame/sec	240	No

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A. SEGMENTATION RESULTS

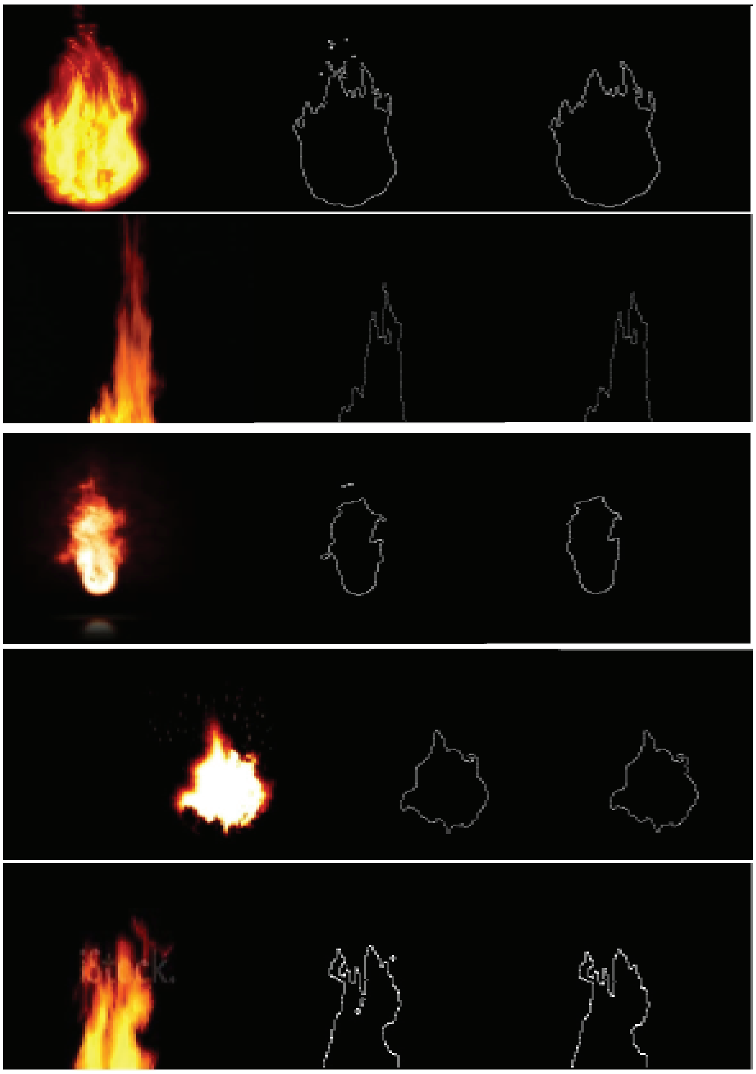

Fig. 7. Segmentation by thresholding (a) On the left is the original image (b) On the middle is the image after segmentation (c) On the right is the segmented image after erasing the small, segmented areas.

II. RESULTS

The researcher evaluated the performance of the proposed fire detection system, Table II shows comparison of the proposed system with state-of-the-art method and Table III shows the detection results.

TABLE II
COMPARISON OF THE PRPOSED SYSTEM WITH STATE OF THE ART METHODS

Method	Accuracy	False +ve	False -ve
Fire and smoke detection using wavelet analysis and disorder characteristics When using RGB [6]	74.2 %	41.18%	7.14%
Fire and smoke detection using wavelet analysis and disorder characteristics When using YUV [6]	87.1%	17.65%	7.14%
Covariance matrix-based fire and flame detection method [7]	90.32%	5.88%	14.29%
An early fire-detection method based on image processing [8]	87.1%	11.76%	14.29%
The proposed system	100%	0%	2.57%

TABLE III
ALARM PERFORMANCE OF THE METHOD

Video Sequences	Fire Alarm (Y/N)	Description
Video 1	Y	Fire
Video 2	Y	Fire
Video 3	Y	Fire
Video 4	Y	Fire
Video 5	N	Car Lights
Video 6	Y	Fire
Video 7	Y	Fire
Video 8	N	Red Ball
Video 9	Y	Fire
Video 10	Y	Fire
Video 11	Y	Fire
Video 12	Y	Fire
Video 13	N	The fire is very far from the camera
Video 14	N	Sunlight

III. CONCLUSION

This research presented a fire detection system based on Fourier descriptors. The system used Fourier descriptors to describe reddish moving objects, and the multi-threshold segmentation method has been used to extract the reddish moving bodies from background. The reddish bodies' features were extracted using Fourier descriptors of reddish bodies' contour where the reddish body contour changes from one frame to another. Fire detection is the last stage of the proposed approach. The proposed approach can detect fires at their beginning when they start with a small flame, and it can also detect large fires provided that the boundaries of the fire are within the range of the surveillance camera used. Also, the system can be used to detect fires in industrial areas and public areas, provided that the fire boundaries are within the range of surveillance cameras. In future work, the researcher should study the effect of high lighting on the accuracy of results when applying the proposed approach. However, in the case of dim lighting, fires are more visible, and applying the proposed method achieves effective results. Future work will also be devoted to smoke detection and expanding the approach to include operating conditions not currently covered.

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