International Journal of
Science and Engineering Investigations vol. 1, issue 4, May 2012
ISSN: 2251-8843

Fire Detection with Image Processing and PIR Sensor

Amaj Chamankar [1], Sasan Mohammadi [2], Mohammad Jamshidian [3]
[1,2] Islamic Azad University South Tehran Branch
[3] Shahrood University of Technology
([1]st_a_chamankar@azad.ac.ir, [2]s_mohammadi@azad.ac.ir, [3]pdambel_dor@yahoo.com)

Abstract- The present paper is aimed at "fire detection" with image processing for detecting the fire and use PIR sensor to detect the temperature to be sure it. All times environment process and every signs of fire survey just with ordinary camera with minimum two mega pixel resolution like security camera or even mobile camera and with knowing its position, fire extinguisher on there. Also with process the color of the flame can know fire material.

With collating these two ways (image processing and PIR sensor using) we can reduce errors in fire detecting process with less cost and more accuracy.

Keywords- *Fire; fire detection; flame; PIR sensor.*

I. INTRODUCTION

Nowadays we can see fire alarm systems everywhere. The main idea of most of them is sensing smoke or temperature or process the environment with IR cameras [1], [6]. Although the smoke sensor provides rapid response time, it has high false-alarm rates. In contrast, the temperature sensor provides more reliable responses but with slow response times [6]. So in [6] smoke and temperature sensor and in [7], [9] multi sensor proposed. In order to cope with these problems, research on video-based fire detection (VFD) has Started in the beginning of this century [11]. The method in [3], [10], [12] is image processing.

Although it has been shown that ordinary video promises good fire detection and analysis results, vision-based detectors still suffer from a significant amount of missed detections and false alarms [11].

Recently, to avoid the disadvantages of visual sensors, the use of time-of-flight (TOF) imaging is started to be explored. TOF cameras are a relatively new innovation capable of providing three-dimensional data from a single sensor [11].

TOF or IR cameras are expensive and they are not in easy access everywhere.

So we decided to use the collation of two ways, detect flames in video by processing the data generated by an ordinary camera monitoring a scene and to ignore errors use PIR sensor.

At first we study on process of flame and its motions. Fire has color and movement and these are good to find it with camera and also flame has high temperature and it's good for be sure it.

Method in [4] is using color analysis and in [3] In addition to ordinary motion and color clues, flame and fire flicker is detected by analyzing the video in wavelet domain.

At first we get a picture from the camera and process it to find the sign of flame, if it observed so check the temperature with PIR sensor. It is shown in Fig1.

For content this subject we test it in different places with different conditions that we had good results and we detect it at the start of the fire. You can study our result in this paper.

In fact we detect fire at the first of its flame.

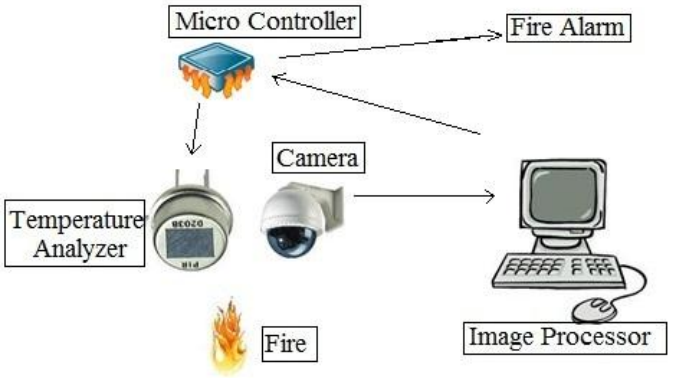

Figure 1: System working block diagram

Camera: one ordinary camera with minimum two mega pixel resolution. This project tested with mobile camera and security camera.

Image processing: Processor for process image and video, that with connect the camera to it, it process the flame signs. It can be a computer or ARM9 or upper processor. In this project we used computer.

Micro Controller: a processor for connecting image processing system to PIR sensor and send a signal to alarm system in hi temperature.

II. IMAGE PROCESSING

For detect the fire with image processing there are some methods. In this paper we use color and movement of the flame to detect the fire. After that take a photo from camera, get the fire color filter and smooth filter on the image to find sign of flame. In this step we test different fire color to have the best result and with this colors we can now what material is fired.

If the flame observe, we test the movement of the flame.

2.1 In image processing at first take a photo:

CvCreateCameraCapture

2.2 change it to picture matrix:

CvQueryFrame

Separating all pixels to their RGB colors.

2.3 Get a copy from picture for several processes.

2.4 Organizing the color of the flame to detect material of the fire.

2.5 Filter the image color:

```
Constant Firecolor (RFC,GFC,BFC) ;
V offset; // offset
For All pixel in Image DO
{
If (R pixel - V offset <RFC< R pixel + V offset
&& G pixel - V offset <GFC< G pixel + V offset
&& B pixel - V offset <BFC< B pixel + V offset)
Set pixel =white;
Else set pixel = black;
}
```

Get a filter in all of the pixels and with this filter all pixels that are in the fire color range will be white and other pixels will be black.

Also with regulating the color ranges it is possible to find material of the fire.

In this project we don't have this alignment.

2.6 Do smooth filter to have a better resolution:

CvSmooth

Strengthen white pixels with 'Gaussian smoothing' or 'Gaussian blur'.

A Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail.

The Gaussian distribution in 1-D has the form:

$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}}$$

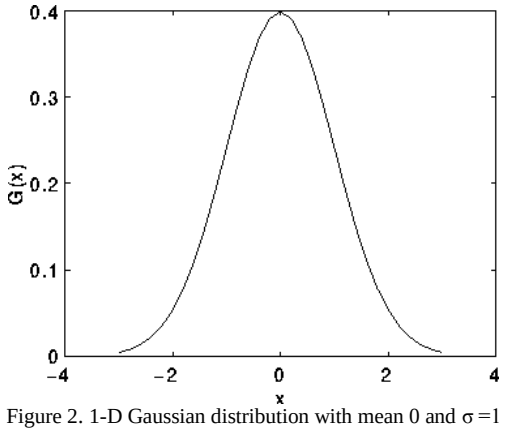

Figure 2. 1-D Gaussian distribution with mean 0 and σ =1

In 2-D, an isotropic (i.e. circularly symmetric) Gaussian has the form:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

This distribution is shown in Figure 3.

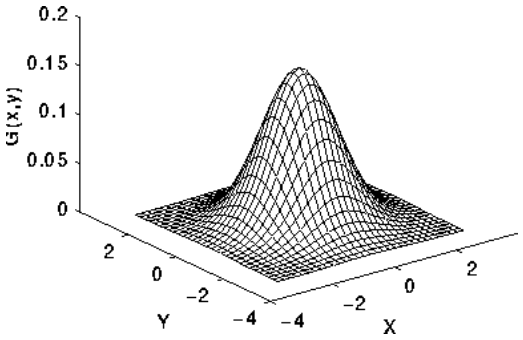

Figure 3. 2-D Gaussian distribution with mean (0, 0) and σ =1

The idea of Gaussian smoothing is to use this 2-D distribution as a `point-spread' function, and this is achieved by convolution. Since the image is stored as a collection of discrete pixels we need to produce a discrete approximation to the Gaussian function before we can perform the convolution. In theory, the Gaussian distribution is non-zero everywhere, which would require an infinitely large convolution kernel, but in practice it is effectively zero more than about three standard deviations from the mean, and so we can truncate the kernel at this point.

2.7 Do "Contour Finding" or "Component Labeling" to detect the flame. It's better to use Contour Finding.

2.8 If with these filtering fire detected we testing fire movement:

DrawOptFlowMap

prevImg =preview image, nextImg =next image
prevImg(x;y)≈nextImg(flow(x;y)[0];flow(x;y)[1])

In other word:
Divide image to segments[n];
For (all of segments of image/*from 0 - n */)
Vector[i]=prevImg.segment[i]-nextImg.segment[i];
Find Maximum (vector [i])//have movement in segment[i];

2.9 If flame didn't has movement go to first.

First we tested the system in the open place with normal weather with mobile camera with two mega pixel resolution.

There are samples of image processing to find the flame that one of them is at day and the other one is at night:

In figure 4 shown that at day at outdoor with maximum sunshine after color filtering in (b) pixels of flame are white and with smooth filtering in (c) we have a good sign of flame and in (d) movement testing show the flame simper.

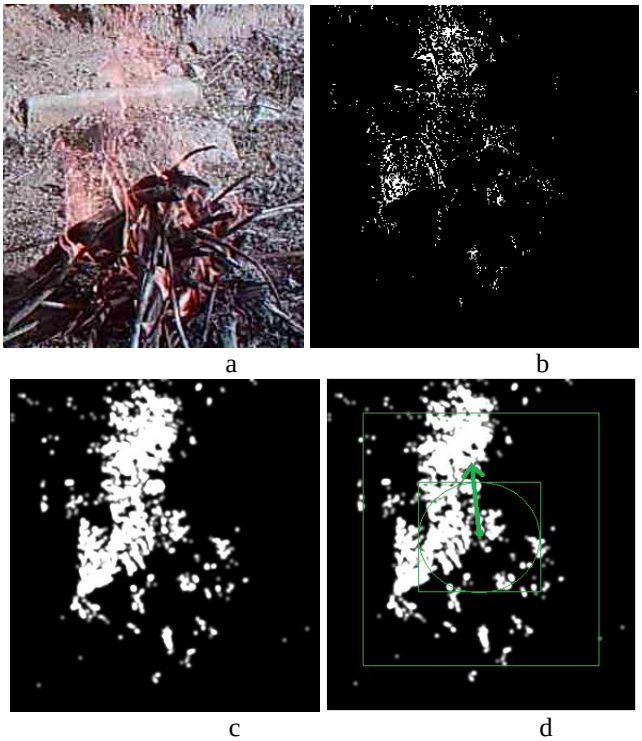

Figure 4. Sample of image processing to find the flame at day in outdoor. a. fire picture b. color filter c. smooth filter d. movement test.

also in figure 5 that we did testing at night, with color (b) and smooth (c) filtering, flame can be observe and movement testing (d) show the flame.

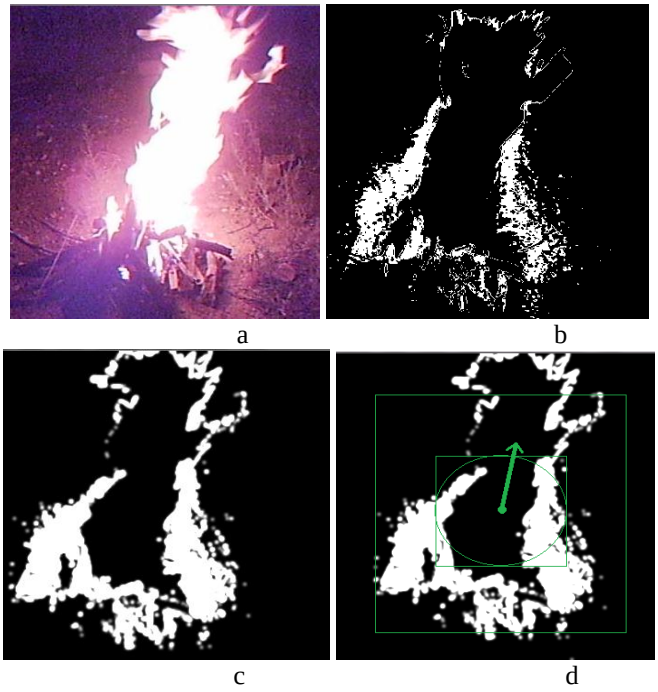

Figure 5. Sample of image processing to find the flame at night in outdoor. a. fire picture b. color filter c. smooth filter d. movement test.

If it had movement go to measure temperature with PIR sensor.

III. PIR SENSOR

A regular camera or typical IR flame sensors have a fire detection range of 30 meters. The detection range of a PIR sensor based system is 5 meters but this is enough to cover most rooms with high ceilings. Therefore, PIR based systems provide a cost-effective solution to the fire detection problem in relatively large rooms as the unit cost of a camera based system or a regular IR sensor based system is in the order of one thousand dollars.[1]

In this paper the PIR sensor data is used to distinguish the flame flicker from the motion of a human being like running or walking. Typically the PIR signal frequency of oscillation for a flickering flame is higher than that of PIR signals caused by a moving hot body [1].

We use "MLX90614" a small size and low cost infrared thermometer for non-contact temperature measurements. Its range is -70 to 380 °C for object temperature [13].

The corresponding circuit for capturing an analog signal output is shown in Fig 6.

Use this circuit to work with sensor, and when camera detects sign of flame we read data from sensor and compare its temperature with our basic standard data. In this project use "AVR atmega16" to get sensor data and sending alarms. In this circuit we use it with SMbus model and receive data with i2c.

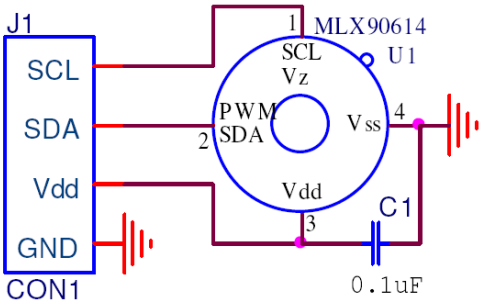

Figure 6

IV. EXPERIMENTAL RESULTS

1) System tested in different places with several conditions and materials. System detected the fire less than 10 second from beginning it and triggers an alarm when fire is detected with camera and within the viewing range of the PIR sensor. Indore and in less distance it detected faster. These results shown in table 1.

2) In 100 fire test. It detected the fire in 97 times but in 3 times it had false alarm in open place because of distance and heavy sunshine. Results shown in table 2.

TABLE 1. Results of system test in different places.

Place testing	**Fire distance (meter)**	**Time of image detect (second)**	**Time of sensor detect (second)**	**Total time (second)**
Office	1-3	5	1	6
Outdoor	2-7	7	3	10
Garage	1-5	5	1	6
Libratory	1-3	5	2	7

In table 1 shown the average of detecting time.

TABLE 2. Test results in different places.

	Fire Test Sequences	Non-Fire Test Sequences
Number of true alarms	97	
Number of false alarms	3	0

The system triggers an alarm when fire is detected with camera within the viewing range of the PIR sensor.

In figure 7 and 8 results of office test are shown. In pictures, steps of image processing are seen and after detecting the flame, PIR sensor after measuring 60^{o}c send the alarm pulse. This is possible to trigger alarm system with another degree and we choose this value with experience and it's depending on environment.

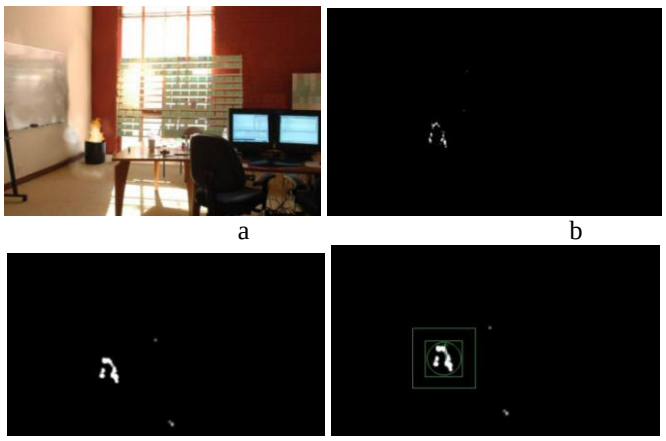

Figure 7: Testing system in office at day with security camera (Campion CN-749HS) and PIR sensor.
a. fire picture b. color filter c. smooth filter d. movement test.

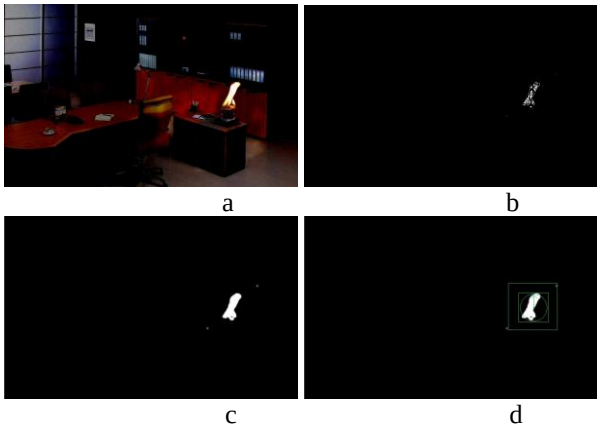

Figure 8: Testing system in office at night with security camera (Campion CN-749HS) and PIR sensor.
a. fire picture b. color filter c. smooth filter d. movement test.

V. CONCLUSION

From the research that has been done, it is possible to build a fire detection system based on video processing ordinary camera data and PIR sensor with high accuracy performance.

One of the advantage of this project is, in image processing with ordinary camera maybe a person with fire color dress detect Also using TOF camera is expensive, but with temperature testing, alarm system don't trigger.

Results shown that combination this two method have no risk for indoor and 97% secure for outdoor. This is a good way with the least cost.

REFERENCES

[1] B. U˘gur T¨oreyin, E. Birey Soyer, Onay Urfalıo˘glu, and A. Enis C¸ etin " FLAME DETECTION SYSTEM BASED ONWAVELET ANALYSIS OF PIR SENSOR SIGNALS WITH AN HMM DECISION MECHANISM" in 16th European Signal Processing Conference,2008.

[2] B. Ugur T¨oreyin, Yigithan Dedeoglu, A. Enis C¸ etin " FLAME DETECTION IN VIDEO USING HIDDEN MARKOV MODELS" Bilkent University, TR-06800 Bilkent, Ankara, Turkey,2005.

[3] Yigithan Dedeoglu, B. Ugur T¨oreyin, Ugur G¨ud¨ukbay, A. Enis C¸ etin " REAL-TIME FIRE AND FLAME DETECTION IN VIDEO" , Bilkent University, TR-06800 Bilkent, Ankara, Turkey,2004.

[4] Wen-Bing Homg, Jim-Wen Peng, and Chih-Yuan Chen " A New Image-Based Real-Time Flame Detection Method Using Color Analysis" 2005, IEEE.

[5] B. Ugur Toreyin, E.Birey Soyer, Onay Urjalzoglu, A. Enis C;etin" Flame Detection Using PIR Sensors" 2008, IEEE.

[6] Jimin Cheon, Jeonghwan Lee, Inhee Lee, Youngcheol Chae, Youngsin Yoo, and Gunhee Han " A Single-Chip CMOS Smoke and Temperature Sensor for an Intelligent Fire Detector" in IEEE SENSORS JOURNAL, VOL. 9, NO. 8, AUGUST 2009.

[7] Haibing Hu Gang Wang Qixing Zhang Jinjun Wang Jun Fang Yongming Zhang " Design Wireless Multi-sensor Fire Detection and Alarm System Based on ARM" in The Ninth International Conference on Electronic Measurement & Instruments, 2009.

[8] Magy Kandil, May Salama, Samia Rashad " Fire Detection Using a Dynamically Developed. Neural Network" 52nd International Symposium ELMAR-2010.

[9] Chen Xiaojuan, Bu Leping " Research of Fire detection Method Based on Multi-sensor Data Fusion" 2010 ,IEEE.

[10] Jenifer.P "Effective Visual Fire Detection in Video Sequences Using Probabilistic Approach" PROCEEDINGS OF ICETECT 2011.

[11] Steven Verstockt, Pieterjan De Potter, Sofie Van Hoecke, Peter Lambert, Rik Van de Walle "MULTI-SENSOR FIRE DETECTION USING VISUAL AND TIME-OF-FLIGHT IMAGING" 2011, IEEE.

[12] Tjokorda Agung Budi W., Iping Supriana Suwardi "Fire Alarm System Based-on Video Processing" in International Conference on Electrical Engineering and Informatics, 2011.

[13] MLX90614 family datasheet, Melexis Co. 3901090614, Rev 006, September 30 2010.

Amaj Chamankar mechatronic & robotic engineering, M.s student Islamic Azad University South Tehran Branch (e-mail: st_a_chamankar@azad.ac.ir).

Dr. Sasan Mohammadi,mechatronic & mechanical engineering Engineering faculty, Islamic Azad University South Tehran Branch, (e-mail: s_mohammadi@azad.ac.ir).

Mohammad Jamshidian, IT engineering, Shahrood university of technology (e-mail: pdambel_dor@yahoo.com).