IJMTST | Volume: 2 | Issue: 02 | June 2016 | ISSN: 2455-3778

A Real Time Image Processing Based Fire Safety Intensive Automatic Assistance System using Raspberry Pi

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ABSTRACT

Fire usually cause serious disasters. Thus, fire detection has been an important issue to protect human life and property. In this project, I propose a fast and practical real-time image-based fire flame detection method based on colour pair analysis and intensity level algorithm. Then, based on the above fire flame colour features model, regions with fire-like colours are roughly separated from each frame of the test videos. Besides segmenting fire flame regions, background objects with similar fire colours or caused by colour shift resulted from the reflection of fire flames are also extracted from the image during the above colour separation process. To remove these spurious fire-like regions, the image difference method and the invented colour masking technique are applied. The device can detect fire by using Artificial Neural Network (ANN). Finally device automatically control the fire safety assistance. This method was tested with Raspberry pi B+ Board interface with camera module.

KEYWORDS: *Fire flame detection method, Artificial Neural Network (ANN),Raspberry pi B+ Board.*

I. INTRODUCTION

Fire is one of the most fateful threaten for mankind. Fire can be determined by light, smoke and temperature. We may resort to power failure, water spraying for alarming. However, fire alarm is still a difficult problem for large space. Because there are many factors such as the height of the space, the heat barrier, the coverage, the signal transmission and so on, it is difficult to control. To detect fire, only using color information may produce false alarm, so color and temporal variation information should be used to get a good performance of a fire detection system. Some researchers used RGB input and the simple and effective procedure for real-time application. Others adopted panoramic camera, wavelet transform, neural networks, etc. for relatively complicated fire detection systems. And some were very specific purposed systems like tunnel fire, ship compartment fire, forest fire, etc. So it is not easy to compare the fire detection systems directly. There are different methods for detecting fire in different features and applications. Sensors are used to measure the desired parameters in most of the methods. Applying several sensors is essential in order to cover all desired area while it is not cost-effective. The sensors are contact sensors. They should be install near the ceiling, thus it causes delay until the smoke reach to them and detect by them.

These restrictions lead to the image processing in fire detection. The characteristics that are used in image processing, are color and motion. If a motion happens in background and the object is the same color as fire, it is consider as fire object but these features cannot produce the required performance. For instance if a red car has a movement in a garage, the system will assumes the motive object as fire. Therefore, an image processing system uses both color and motion characteristics for proposed applications in different conditions. Moreover, the other features such as dynamic movement and disorder, in the shape of fire and smoke, should be used for high performance detection. The color feature is a static characteristic and it depends on the fuel. The motion is a dynamic characteristic and it highly depends on the airflow. The growth and disorder features are also dynamic characteristics and they depend on fuel and

airflow. The fire is judged by the one of the Computational Intelligence techniques called Advanced Neural Network (ANN) with the feature parameters as input element which solves pattern recognition problem and their parallel architectures.

II. Terminologies used in the Proposed System

A. *Color Space:*

Color space is used to represent every kind of color in the real world to the computer. To produce the color, we control the luminance value and the chromatic value or by combining the color. RGB can be said as the electronic color model where the color is from the combination of the R, G and B value so the combination of the three values is unique one among the others. Color models have five major categories, which are CIE, RGB, YUV, HSL/HSV and CMYK.

B. *Artificial Neural Networks:*

Artificial Neural Networks (ANNs) area branch of the artificial intelligence and non-linear mapping structures based on the function of the human brain.ANN possesses the abilities to recognize patterns, manage data and learn like the brain. The weights and the input-output function (transfer function) that is specified for the units are used to characterize the behavior of an ANN. The most significant pros in using artificial neural networks are solving the very complex problems of conventional technologies, not formulating an algorithmic solution or using the very complex solution.It is a massively parallel distributed processing system made up of highly interconnected neural computing elements that has the ability to learn and thereby acquire knowledge and make it available for use. They are powerful tools for modelling, especially when the underlying data relationship is unknown. After training, ANNs can be used to predict the outcome of new independent input data. ANNs imitate the learning process of the human brain and can process problems involving non-linear and complex data even if the data are imprecise and noisy. Thus they are ideally suited for fire images which are known to be complex and often non-linear.

III. Hardware used in the Proposed System Raspberry Pi B+ Board

The Raspberry Pi is a basic embedded system and being a low cost a single-board computer used to reduce the complexity of systems in real time applications.It has around the same computing power as a smart phone.

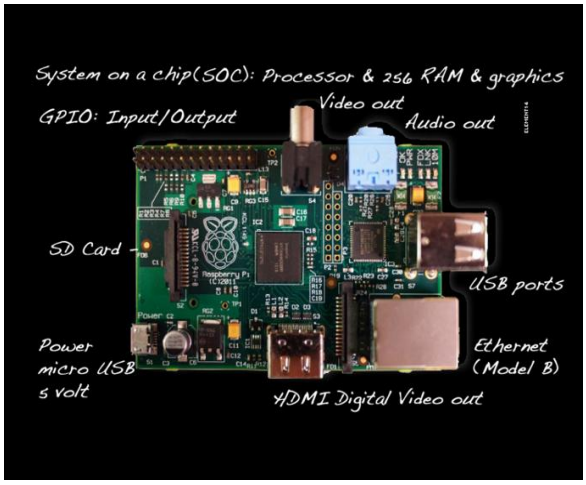

Fig 1: Specifications of Raspberry Pi

The Raspberry Pi is manufactured in three board configurations through licensed manufacturing deals with Newark element14 (Premier Farnell), RS Components and Egoman.

The Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, VideoCore IV GPU and was originally shipped with 256 megabytes of RAM, later upgraded (Model B & Model B+) to 512 MB. It does not include a built-in hard disk or solid-state drive, but it uses an SD card for booting and persistent storage, with the Model B+ using a MicroSD.

The implementation of image processing operations on Raspberry Pi is starts with interfacing of raspberry pi camera in Camera slot Interface (CSI). The camera module attaches to Raspberry Pi by a 15 pin Ribbon Cable, to the dedicated 15 pin MIPI Camera Serial Interface (CSI), which was designed especially for interfacing to cameras. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data to the BCM2835 processor.Here, the Dark and Low contrast images captured by using the Raspberry Pi camera module are enhanced in order to identify the particular region of image.

IV. Working of Proposed System

A. *Extraction of flame image:*

Each color corresponds to the basic spectrum factors of red R, green G, and blue B in the RGB model. The color model is based on the Cartesian coordinate system. The color subspace is a cube, as shown in Fig. 2

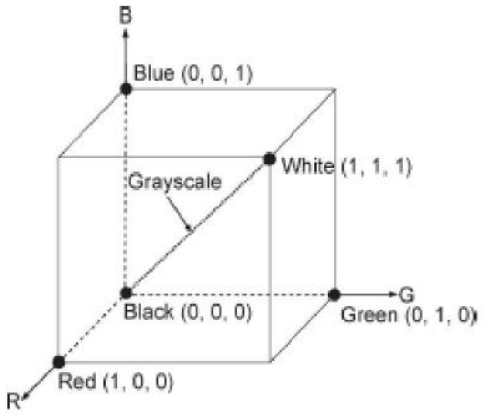

Fig 2:RGB color cube

The RGB value consists of three vertexes, one black point, and one white point, where black and white arethe original point and the farthest vertex point from the original point, respectively. The grayscale color is spread along the line that connects two white points from the black color in this model, and the color is onthe cube space or the inside point that is defined as the vector that is extended from the original point. RGB color cube.

In this paper, the original RGB images are applied as images converted to grayscale. The following conversion (1) is a conceptual expression as shown in Fig. 1. However, (2) is used in practical applications.

In this paper, (2) is also applied to convert the RGB color to grayscale.

$$Gray = \frac{R + G + B}{3} \quad (1)$$

$$Gray = (0.30 \times R) + (0.59 \times G) + (0.11 \times B). \quad (2)$$

For comparison, a value of each color in a pixel (x,y) in the one-frame image fN is defined as fN (x Y) [3,4] (Equation (3)). A value in thebackground image is similarly defined as
B (x'Y) (Equation (4)), and these difference values fout (x, Y) are calculated by formula (5).This the threshold defined by considering noise. This processingfor the all pixels extracts pixels estimated to be flame.

$$f_N(x,y) = \left(R_N(x,y), G_N(x,y), B_N(x,y)\right) \quad (3)$$

$$f_B(x,y) = \left(R_B(x,y), G_B(x,y), B_B(x,y)\right) \quad (4)$$

$$f_{out}(x,y) = f_N(x,y) \text{ if } R_N(x,y) - R_B(x,y) > Th,$$

$$f_{out}(x,y) = (0,0,0) \quad \text{if } R_N(x,y) - R_B(x,y) \le Th \quad (5)$$

Where

$f_N(x,y)$: Pixel in one-frame image

$R_N(x,y), G_N(x,y), B_N(x,y)$:

Red, Green, Blue intensity of $f_N(x,y)$

$f_B(x,y)$: Pixel in background image

$R_B(x,y), G_B(x,y), B_B(x,y)$:

Red, Green, Blue intensity of $f_B(x,y)$

f_{out} : Pixel in output image

Th: Threshold

The images captured by the Camera are converted from RGB to *XYZ* color space. The *XYZ* color space converted image is segmented using anisotropic diffusion segmentation.

B. Fire detection by ANN:

The Artificial Neural Network (ANN) is trained with the images of confined areas with the presence of fires (i.e.) the space values of the pixels that belong to fire regions. For a given *XYZ* color space value of a pixel, the trained radial basis function neural network will identify whether that pixel corresponds to a fire region or not.

Input data is a total of Red, Green and Blue. The middle class and output layers two units of a fire output and a non-fire output.

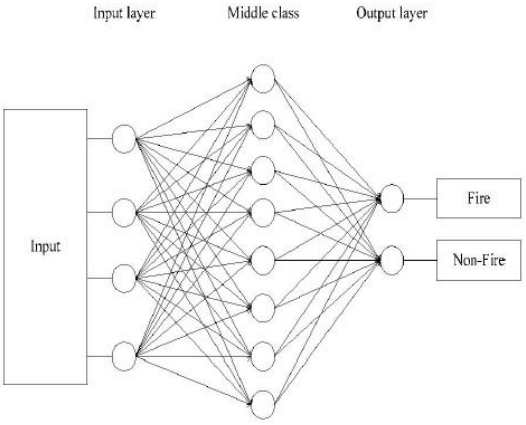

Fig 3: Outline of ANN

The safety assistance actions are included with the image processing code. Run the code with the above process after enabling the camera settings

on the board to capture the image and save it on the folder.

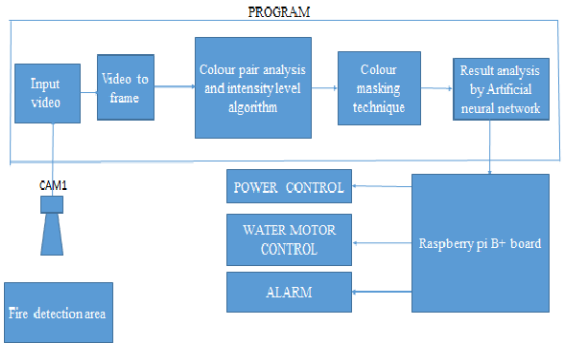

Fig 4: Proposed system block diagram

V. RESULTS

A. *Simulation result:*

Fire Detection program which analysis the given image with fire or not, the MATLAB R2010a is utilized. The following figure shows the simulation results.

The fig 5 shows the input image which is the contrast unenhanced truecolour composite.

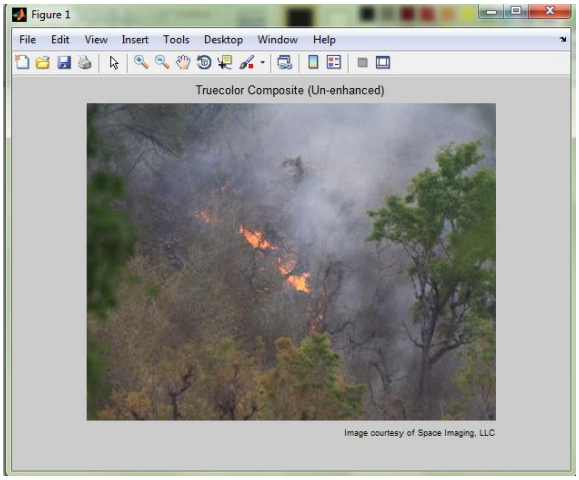

Fig5: Truecolour image i.e. input image(unenhanced)

The fig 6 showsthe extraction of Red, Green and Blue images respectively.

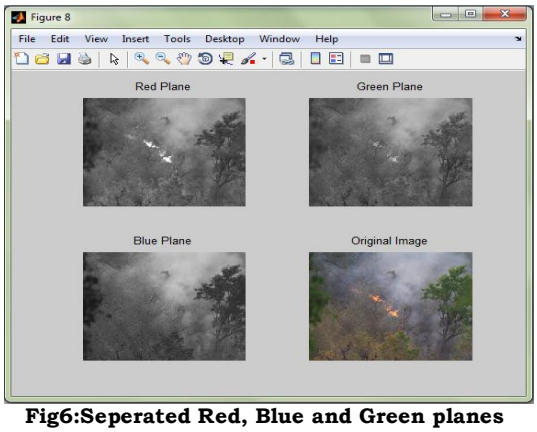

Fig6:Seperated Red, Blue and Green planes

The separated RGB images are converted into binary scale images which is used for the fire analysis by ANN. The fig 8 shows the Binary images of the RGB image.

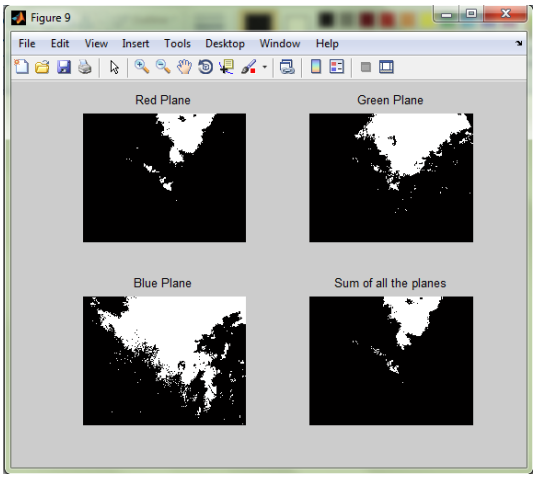

Fig 7:Binary image for RGB planes.

The fire image is detected by ANN which gives the instructions to the Raspberry pi controller to start the safety measures activity through by switch on the Alarm, power off the electrical line and start the motor connected to the water tank.

B. *Hardware Results:*

The python program is executed. The Executed python program allow the camera capture the image for a 2 second. From the captured image the analysis of fire is carried out. If the image is detected as a fire image through comparing the thousands of possibilities, then the alarm is started and motor is ON.

The fig 8 shows the full setup of the real time fire detection device as per connection showed in block diagram fig 4.

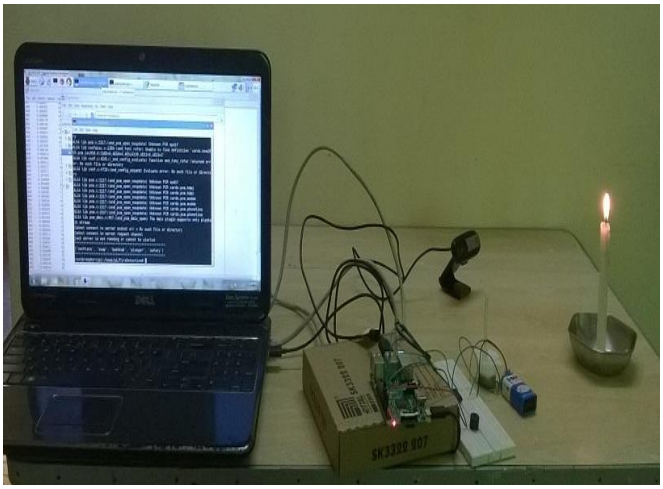

Fig 8: Fire Detection devicewith Raspberry Pi B+ Board

The fig 21 shows the GPIO 10 and GPIO 9 pin is connected to the motor and buzzer to provide the after fire actions

Fig 9: The connection to motor and alarm

The fig 10 shows the captured image by the camera after execution which is the image used for the analysis using ANN.

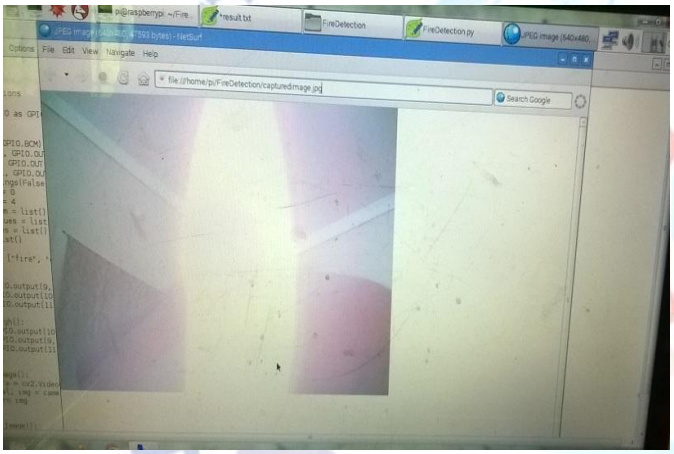

Fig 10: The captured output image

VI. Conclusion

The most important goals in fire surveillance are Real time, quick and reliable detection and localization of the fire is achieved by Artificial Neural network with the help of Raspberry pi board which provides the real time image processing. Thus the proposed paper aims to detect fire occurrence while it is in its early stages so that it is much easier to suppress a fire and prevent loss of property and invaluable human lives.

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