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Fire Recognition based on Image Processing using Raspberry pi

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Abstract: ***Fire is a procedure of ignition that brings calamity. It becomes unsafe when fire loses control and spreads out. The fire detection becomes more and more important with the rapid development of image and video processing, the fire detection technology based on video processing is becoming the focal point of some research due to its advantages of high intuitive, speed and anti-jamming capability. This method uses colour and motion information extracted from video sequences to detect fire. It can work both indoor and outdoor environments. Moreover, it detects fire at the beginning of the burning process. The method performs the region growing segmentation to identify colour pixels in the scene and then identify moving pixels based on the ratio of height and width of suspected fire region. This method can get low false alarm rate by eliminating the fire-like colours because it just needs a fire pixel as the seed pixel. .***

Keywords: GMM, GPIO, GPS, Open CV, RPi, SoC

I. INTRODUCTION

Video fire detection technology is a new technology which has just been applied in fire detection during the last few decades. Compared with conventional methods such as smoke detection and temperature detection, video fire detection method is timelier, more intelligent and more reliable as it's a non-contact detection method. Generally, an ordinary color camera is used to shoot videos of the scene, and some unique features of fire such as color and shape are extracted as the input of the recognition algorithm for fire detection. As the most representative feature of the fire, color is often used in the video fire detection. A lot of fire color analysis have been down by researchers at home and abroad, which bring about different fire color models in different color spaces. Chen et al established a fire color model in RGB and HSI color space. The model can extract target areas accurately and clearly, but it can not rule out the interference of electric welding, fluorescent lights and other non-fire objects. Celik et al created a fire color model in YCbCr color space, which can effectively eliminates the interference of non-fire objects. However, the fire areas extracted through this model is not accurate, which limits its wide application in video fire detection.

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Chen Wei et al proposed a fire color model based on its distribution in HSI color space. This model is robust to the change of illumination intensity, but it can't distinguish the fire from suspected target areas, which leads to the error detection.To overcome the shortages of above video fire detection methods, we first integrate present the dispersion of the color components into Chen's RG B-HSI color model, then we present an improved fire detection algorithm using hierarchical nature of the fire.

The fire tracking can be done with many methods:

- Color Detection
- Moving Object Detection
- Spatial Wavelet Color Variation and Analysis

Color Detection

Shading location was one of the primary discovery methods utilized in VFD is as yet utilized in practically all identification techniques. Most of the shading based approaches in VFD utilize RGB shading space, once in a while in mix with HSI/HSV immersion.

The principle purpose behind utilizing RGB isthat almost all visible range cameras have sensors detecting video in RGB format and there is the obvious spectral content associated with this color space. It is reported that RGB values of flame pixels are in the redyellow color range indicated by the rule (R>G>B) similarly, in smoke pixels, R, G, and B values are very close to each other. More complex systems use rule-based techniques such as Gaussian smoothed color histograms, statistically generated color models and blending functions.

It is obvious that color cannot be used by itself to detect fire because of the variability in color, density, lighting, and background. However, the color information can be used as a part of a more sophisticated system

Object, further analysis of moving regions in video is necessary.

Well-known moving object detection algorithms are background (BG) subtraction methods, temporal differencing, and optical flow analysis. They can all be used as part of a VFD system.

Spatial Wavelet Color Variation and Analysis:

Flames of an uncontrolled fire have varying colors even within a small area. Spatial color difference analysis focuses on this characteristic. The concept of spatial difference analysis is further explained by means of a histogram-based approach, which focuses on the standard deviation of the green color band. It was observed by Qi and Ebert that this color band is the most discriminative band for recognizing the spatial color variation of flames. This can also be seen by analyzing the histograms. If the standard deviation of the green color band exceeds tσ¼50 in a typical color video the region is labeled as a candidate region for a flame.

For smoke detection, on the other hand, experiments revealed that these techniques are not always applicable because smoke regions often do not show as high spatial color variation as flame regions.
Furthermore, textured smoke-colored moving objects are difficult to distinguish from smoke and can cause false detections. In general, smoke in an uncontrolled fire is gray and it lessens the shading variety out of sight. Accordingly, in YUV shading space we hope to have decrease in the dynamic scope of chrominance shading segments U and V after the presence of smoke in theviewing range of camera.

A. Hardware and Software

RASPBERRY PI

The Raspberry pi is small sized computer CPU developed by Raspberry Pi Foundation UK Charity . The Raspberry Pi is started with purpose of teaching computer science in schools and colleges but now it is used by experts and professionals for business. It is an amazing device that packs a fully-functional Linux computer into a single chip showcasing low power and cooling requirements. Naturally, the Pi is perfectly suited for DIY projects of all types. The Raspberry Pi based systems are cheap and easy to obtain and store, the forum support for the Raspberry Pi is also good when compared to other similar boards.

B. Hardware specification:-

The Raspberry Pi 3 is based on the Broadcom BCM2837 system on a chip (SoC),which includes an ARM Cortex-A53 of 1.25 GHz quad core processor, VideoCore IV GPU, and has 1 GB of RAM. The system has MicroSD socket for boot media and persistent storage. It also has 4 USB ports, 40 GPIO pins, Full HDMI port, Ethernet port, Combined 3.5mm audio jack and composite video, Camera interface (CSI), Display interface (DSI), Micro SD card slot and Video Core IV 3D graphics core.

C. Benefits of raspberry pi:-

Raspberry Pi shown in Figure 2.1 is as small as the size of a credit card. It works as if a normal computer at a relatively low price. It is possible to work as a low-cost server to handle light internal or web traffic. Grouping a set of Raspberry Pi to work as a server is more cost-effective than

Raspberry Pi Board a normal server. If all light traffic servers are changed intoRaspberry Pi, it can certainly minimize an enterprise's budget. Raspberry pi can be used to capture high-altitude shots if you outfit it with the proper camera and GPS sensor, the latter of which will help you find the device after it returns to Earth. Main advantage of Raspberry pi is that it is small in size having all function of laptops and desktop. Raspberry pi computer draws very less power that you can't imagine, it consume about five to seven watts of electricity. Raspberry pi computer uses an SD card for storage, which is fast and has no moving parts. Raspberry Pi does not have fans or other things which are movable, if you use Class 10 SD card which is the best performing compared to lower class cards, but this will mainly only affect boot time where there is the most I/O. Raspberry Pi systems are noise free which is one of the great features. There are

Web Camera for Raspberry Pi 11

many options for light notification in Raspberry Pi motherboard. If you have transparent case then you can see NIC activity, disk I/O, power status, etc.
Future expansion capabilities – This is a feature which attracted many professional towards raspberry Pi computer is that it has many expansion capabilities whether it's about RAM, camera module, HDD and Wi-Fi dongles etc. It's a highly customizable computer
Affordable Pricing - It is very affordable with extreme feature which you will not get in branded computers in the market. That's why it is very useful in home automation over the years.
Built-in HDMI capable graphics - It is armored with built-in HDMI capable graphics.
Overclocking ability - The Pi can be overclocked if there is execution issue with the application utilized,
in any case, it is at the client's hazard to do this.
Various utilizes - Having the capacity on a SD card makes it simple to swap with other SD cards running other
GNU/Linux dispersions to rapidly and effectively change the usefulness of thePi.
The Raspberry Pi 3 takes the platform to a completely new level. Combining a six fold increase in processing power and a doubling of memory capacity with complete backward compatibility with the existing Model B+, Raspberry Pi 3 is the perfect board for professionals and hobbyists alike. With a new quad core processor and twice the memory with a massive 1GB RAM, It is 6x faster than its predecessor. Hence Raspberry Pi 3 is chosen for this project.

CAMERA MODULE:-

RPi Web Cam is shown in Figure 2.2 It very well may be utilized for a wide assortment of utilizations including reconnaissance, recording and time pass photography.
It is exceptionally configurable and can be reached out with the utilization of full scale contents. It tends to be opened on any program. Contains the accompanying highlights: View, stop and restart a live-see with low inactivity and high framerate.

Full sensor zone accessible. Control camera settings like brilliance, differentiate, live Record full-hd recordings and spare them on the sd-card stuffed into mp4 holder while the live-see proceeds.

Screen Mode

Typically movement location is just dynamic when movement identify is fired up. A screen mode can be chosen which enacts the base interior movement location however doesn't create triggers to the scheduler. When
chosen it will be dynamic during typical account or in any event, when not recording giving video buffering is utilized.

PIEZO BUZZER

Piezo buzzer is an electronic device commonly used to produce sound. A piezo electric buzzer can be driven by an oscillating electronic circuit or other audio signal source. A click, beep or ring can indicate that a button has been pressed. The Piezo buzzer can work over a wide range of voltage from 1.5 to 24v DC and consumes current as low as 1mA.

II. RASPBERRY PI COMPATIBLE OPERATING SYSTEMS:-

Some of the big operating systems working with the Raspberry Pi are discussed below.

Raspbian

Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware. An operating system is the set of basic programs and utilities that make your Raspberry Pi run. However, Raspbian provides more than a pure OS: it comes with over 35,000 packages, pre-compiled software bundled in a nice format for easy installation on your Raspberry Pi.

(1)

Open ELEC

OpenELEC is a media centre that takes music, photos and videos served by other devices on your network, streamed channels or files from an attached drive, and allows you to play them back via your monitor or TV. It works well on the original Pi, and is able to play back 1080p video, but the interface is far more responsive on the Pi2.

Pidora,

Pidora is another Linux distribution like Raspbian, but is based on the Fedora distribution. It gives you a different look and feel to Raspbian. The current build is for the **ARMv6 architecture, and therefore will not run on the Pi2.**

Risc OS

b)

This operating system is different from the others in the fact that it is not based on Linux, but is instead a completely separate OS. It was originally designed by Acorn in Cambridge and has links to the team that developed the original ARM microprocessors.

Snappy ubuntu core

With the advent of the ARMv7 in the Raspberry Pi2, a version of the Ubuntu Linux operating system has become available. This is an early, alpha release, which means that it is not really intended for everyday users, but more for developers to start developing "snappy" apps for Ubuntu.

Arch linux is another distribution for more experienced users. The base OS is minimal and needs additional packages to be installed by the user to make up the OS in to a full environment. However it has the reputation of being a good stable distribution .

The OS chosen for this project is Raspbian Wheezy. It is specially meant for Raspberry Pi 2. The reason behind this is, the Raspbian Wheezy is written to run on the ARMv7 architecture. This OS could not run on the older models of Raspberry Pi since they were based on ARMv6 architecture. Being based on Debian, Raspbian comes with the APT (Advanced Packaging Tool) as it's package manager, which is used to install software from the vast Raspbian repositories, but Raspbian also comes with raspi-config, a menu based tool that simplifies the act of managing Raspberry Pi configurations such as setting up an SSH, overclocking and enabling the official Raspberry Pi camera. Since December 2014 the Raspbian desktop has received a notable improvement to its user interface. The RPi.GPIO library enables Python to talk to the GPIO (General Purpose Input Output) pin.

III. IMAGE PROCESSING LIBRARIES

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. There are several image processing libraries available.

Some of them are discussed below.

OpenCV

OpenCV is an open source computer vision library originally developed by Intel. It is free for commercial and research use under a BSD license. The library is cross-platform, and runs on Mac OS X, Windows and Linux. It focuses mainly towards real-time image processing.

CImg CImg stands for Cool Image. It is a small, open-source, and modern C++ toolkit for image processing. It defines classes and methods to manage images in your own C++ code. It is self-contained, thread-safe and highly portable. It fully works on different operating systems (UNIX,Windows,MacOSX ...) and is compatible with various C++ compilers (Visual C++,g++,clang++,icc...).

PINK

PINK is an image processing library originally developed at ESIEE Engineering for research and teaching purposes. It contains implementations of over 200 algorithms for image segmentation and filtering. Most of the operators come from mathematical morphology, but it contains operators from different fields. It is free software licensed under the CeCILL license.

Image Magic

ImageMagick is a software suite to create, edit, compose, or convert bitmap images. It can read and write images in a variety of formats (over 200) including PNG, JPEG, JPEG-2000, GIF, TIFF, DPX, EXR, WebP, Postscript, PDF, and SVG. Among these libraries OpenCV is chosen for this project since it was designed for computational efficiency and with a strong focus on real-time applications. Written in optimized C/C++, the library can take advantage of multi-core processing.

OpenCV

Computer vision is everywhere-in security systems, manufacturing inspection systems, medical image analysis, unmanned aerial vehicles, and more.

OpenCV provides an easy-to-use computer framework and a comprehensive library with more than 500 functions that can run vision code in real time. OpenCV has out of the box support for USB cameras and provides various libraries for object detection, recognition, tracking and many more applications. Since OpenCV after compilation needs a large amount of memory, it is always good to use a memory capacity of 8GB or more. The interfaces of OpenCV are:

- C
- C++
- Python
- Java (Android)

OpenCV 3.1.0 and Python interface is used in this project to implement the background subtraction algorithm.

OpenCV 3.1.0 introduced many new algorithms and features comparing to version 2.4. Some modules have been rewritten, some have been reorganized.

Although most of the algorithms from 2.4 are still present, the interfaces can differ. OpenCV STRUCTURE AND CONTENT :OpenCVis broadly structured into five main components, four of which are shown in Figure 2.3.

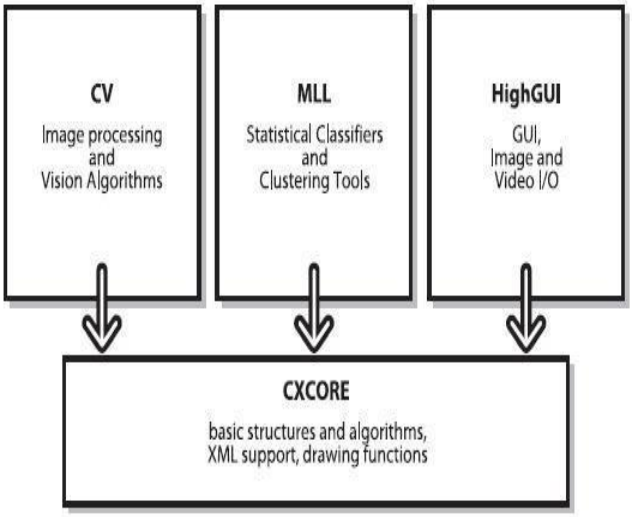


Figure 2.4 Basic structure of OpenCV

CXCORE

CXCORE is a compact module defining basic data structures, including the dense multi-dimensional array Mat and basic functions used by all other modules.

CV

The CV component contains the basic image processing,structural Analysis, motion Analysis and object tracking reference pattern recognition, camera calibration and 3D reconstruction and higher-level computer vision algorithms

MLL

ML is the machine learning library, which includes many statistical classifiers and clustering tools, normal bayes classifier, K nearest neighbors, support vector machines, decision trees, boosting, random trees, expectation-maximization and neural networks.

HighGUI

HighGUI contains I/O routines and functions for storing and loading video and images. It has three parts as described below.

The hardware part is primarily concerned with the operation of cameras. It allows an easy way to query a camera and retrieve the latest image from the camera.

The file framework part is concerned basically with stacking and sparing pictures. One pleasant element of the library is that it permits to peruse video utilizing similar strategies it would use to peruse a camera..

The third piece of HighGUI is the window framework (or GUI). The library gives some basic capacities that will open a window and toss a picture into that window. It additionally permits to enroll and react to mouse and console occasions on that window.

CVAUX

CVAUX contains both defunct areas (embedded HMM face recognition) and experimental algorithms (background/foreground segmentation). It covers Eigen objects, a computationally efficient recognition technique that is, in essence, a template matching procedure, 1D and 2D hidden Markov models, a statistical recognition technique solved by dynamic programming, Embedded HMMs (the observations of a parent HMM are themselves HMMs), Gesture recognition from stereo vision support, background-foreground segmentation etc.

IV. APPLICATIONS OF OPENCV

Figure 2.4 shows the list of some of the key function categories included in the OpenCV. These range from low-level image filtering and transformation to sophisticated feature analysis and machine learning functionality.

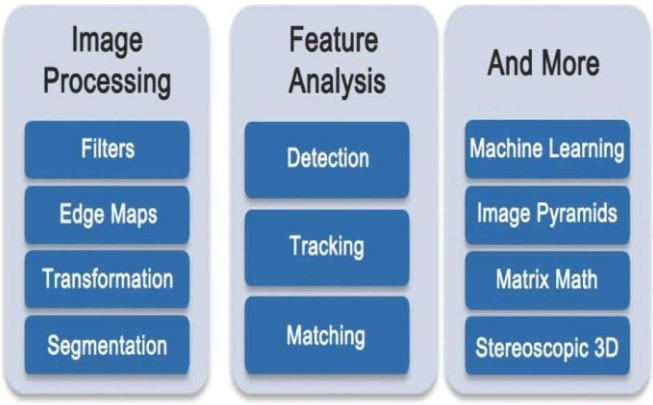


Figure 2.5 OpenCV applications

Image processing

Image processing is to help the computer to understand the content of an image (features extraction such as color, shapes of the objects). Transformation function performs various geometrical transformations of 2D images. They do not change the image content but deform the pixel grid and map this deformed grid to the destination image. Segmentation partitions an image into distinct regions containing each pixel with similar attributes. To be meaningful and useful for image analysis and interpretation, the regions should strongly relate to depicted objects or features of interest.

Feature analysis

Object detection and tracking is a basic part in numerous applications, for example, picture search, scene understanding, and so on. Anyway it is as yet an open issue because of the assortment and multifaceted nature of article classes and foundations. The least demanding approach to identify and portion an article from a picture is the shading based techniques. The article and the foundation ought to have a huge shading distinction so as to effectively detect objects using color based methods.

Template Matching is a method for searching and finding the location of a template image in a larger image. OpenCV comes with a function cv2.matchTemplate() for this purpose. It simply slides the template image over the input image (as in 2D convolution) and compares the template and patch of input image under the template image.

Image pyramids

Normally, images of constant size are used. But in some occasions, pictures of various goals of a similar picture are required. For instance, while looking for something in a picture, similar to confront, it isn't sure that at what size the item will be available in the picture. All things considered it is important to make a lot of pictures with various goals and quest for object in every one of the pictures. These arrangement of pictures with various goals are called Image Pyramids (because when they are kept in a stack with biggest image at bottom and smallest image at top look like a pyramid).cv2.pyrUp() and cv2.pyrDown() are the functions used for this purpose.

d) OpenCV Vs MATLAB

Although MATLAB is an easy and pretty high-level scripting language and do image processing, OpenCV has the following advantages over it.

Speed:

Matlab is based on Java, and Java is based upon C. So when you run a Matlab program, your PC is occupied with attempting to translate all that Matlab code. At that point it transforms it into Java, and afterward at last executes the code. OpenCV, then again, is fundamentally a library of capacities written in C/C++.

You are nearer to legitimately give machine language code to the PC to get executed. So at last you accomplish more picture preparing for your PCs handling cycles, and not more deciphering. Subsequently, programs written in OpenCV run a lot quicker than comparative projects written in Matlab. Along these lines, OpenCV is damn quick with regards to speed of execution. For instance, we may compose a little program to recognize people groups grins in an arrangement of video outlines. In Matlab, we would normally get 3-4 casings broke down every second. In OpenCV, we would get at any rate 30 edges for every second, coming about in realtime location.

Assets required:

resources.Matlab code requires over a gigabyte of RAM to run through video. In comparison, typical OpenCV programs only require ~70mb of RAM to run in realtime.

Cost:

Rundown cost for the base (no tool compartments) MATLAB (business, single client License) is around USD 2150.OpenCV(BSD permit) is free.

Compactness:

MATLAB and OpenCV run similarly well on Windows, Linux and MacOS. In any case, with regards to OpenCV, any gadget that can run C, can, more likely than not, run OpenCV

V. RESULTS AND DISCUSSION

FIRE DETECTION

The fire detection system involves the steps such as RGB color analysis, apply color-based modelling to detect fire pixels and fire pixel analysis.

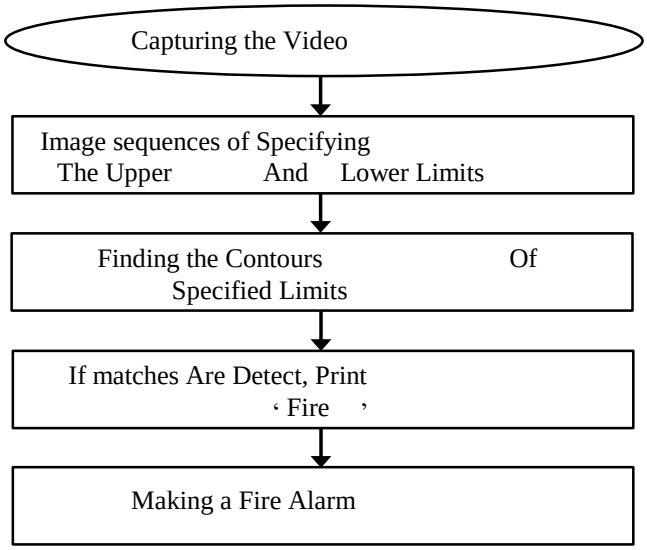
INPUT VIDEO OF FIRE

The following sample video is given to detect the presence of fire at any environmental circumstances with the following characteristics.

Type of file	:MP4 Video(.mp4)
Frame width	:853
Frame rate	:24 frames/second
Frame Resolution	: 480p/MP4

FLOW DIAGRAM

The step by step process of fire detection system is shown in



RGB COLOR ANALYSIS

The RGB color model is an additive color model in which red, green and blue light are added together in various ways to reproduce a broad array of colors.

The main purpose of the RGB color model is for the sensing, representation and display of images in electronic systems.

Red channel of fire pixels should be higher than their green channel and their green channel should be higher than their blue channel.

The detection of fire in the video is done by using the following pixel ranges are R(250-255), G(230-255), B(150-190).

DETECT FIRE PIXEL AND ANALYSIS

A fire detection procedure based on R, G, B color channels and saturation of given ranges. It is a fast and efficient method and the have been used in other fire detection methods.

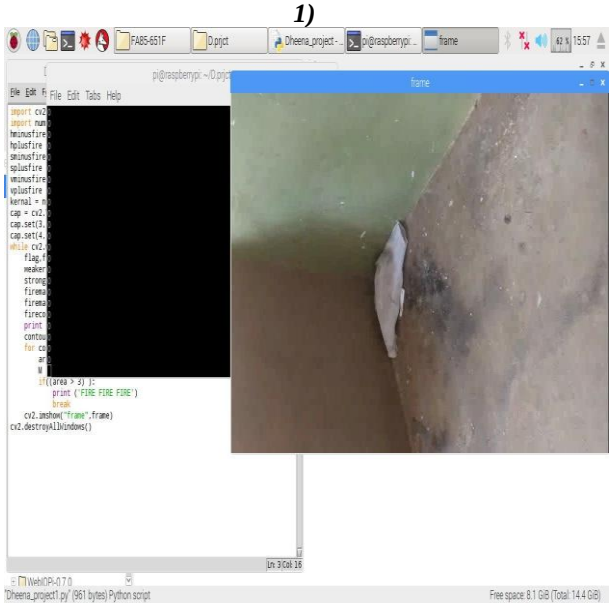
e) RESULTS

DAY TIME FIRE DETECTION

DURING THE ABSENCE OF FIRE IN DAY TIME

Zero is printed on the screen, when there is no fire is detected in the given image frame during presence of sunlight (i.e. Day Time).

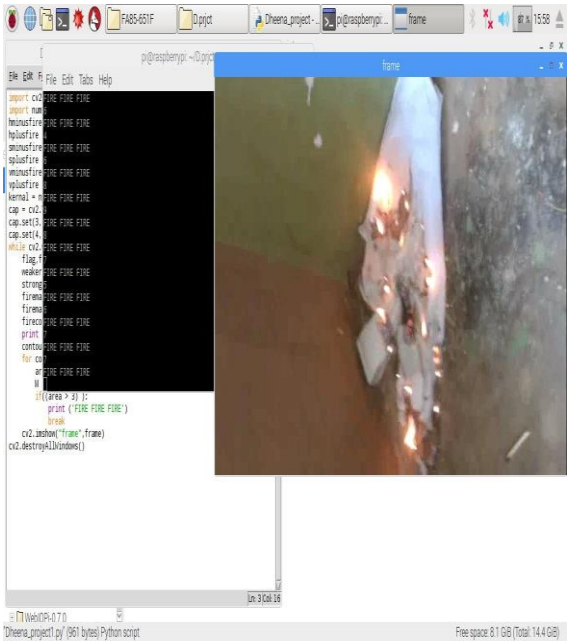
1)



During The Absence of Fire in Day Time

DURING THE PRESENCE OF FIRE IN DAY TIME

The pixels which are in the range to detect through the length of contours. Satisfy the certain (to limits very small contours). They were detect the pixels which represent the fire in the presence of sunlight (i.e. Day Time).

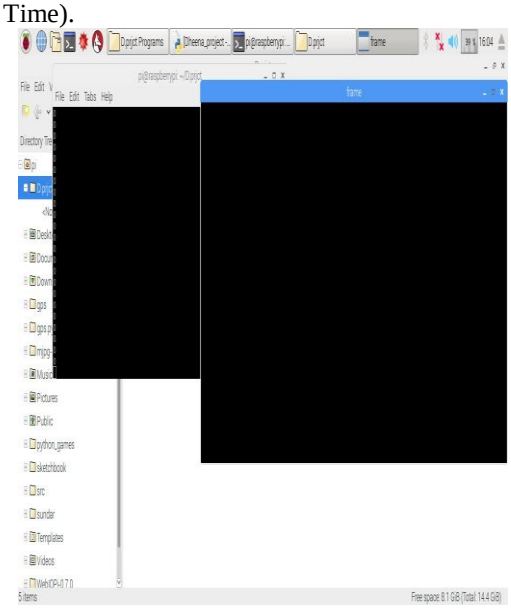


During The Presence of Fire in Day Time

NIGHT TIME FIRE DETECTION

DURING THE ABSENCE OF FIRE IN NIGHT TIME

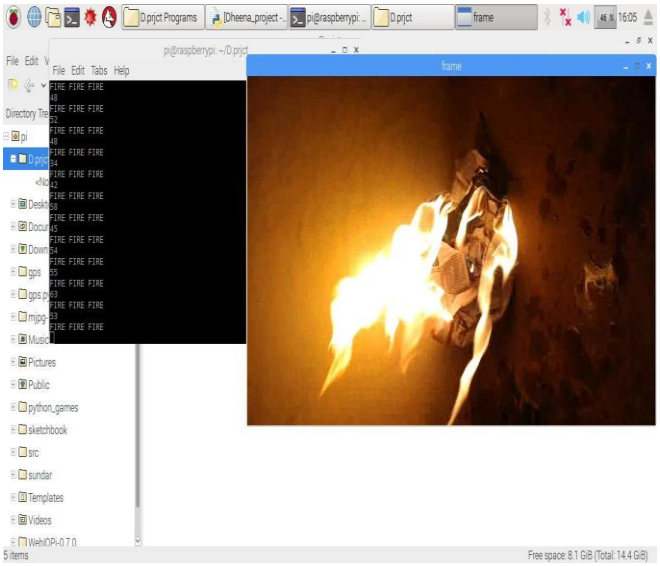
Zero is printed on the screen, when there is no fire is detected in the given image frame during absence of fire(i.e. Night Time).



During The Absence of Fire in Night Time

DURING THE PRESENCE OF FIRE IN NIGHT TIME

The pixels which are in the range to detect through the length of contours. Satisfy the certain(to limits very small contours). They were detect the pixels which represent the fire.

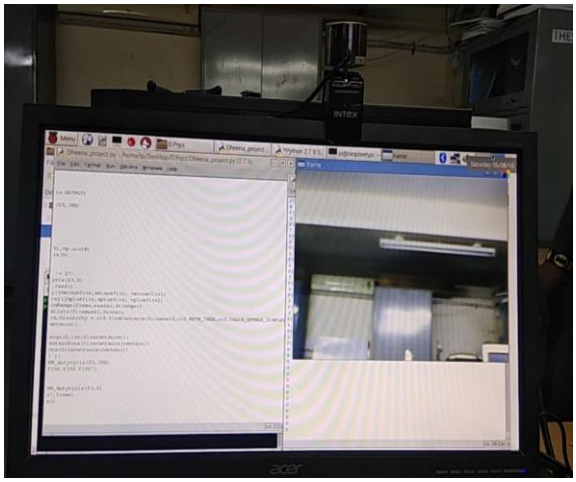


During The Presence of Fire in Night Time

REAL TIME FIRE DETECTION

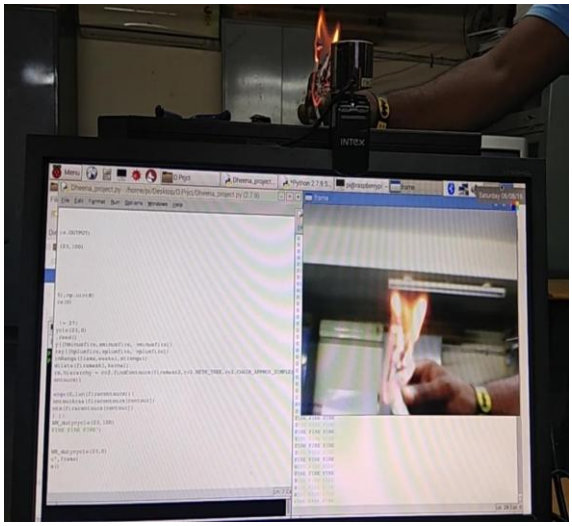
DURING THE ABSENCE OF FIRE IN REAL TIME

Zero is printed on the screen, when there is no fire is detected in the surveillance camera directly interface to the Raspberrry Pi.



During The Absence of Fire in Real Time

DURING THE PRESENCE OF FIRE IN REAL TIME



VI. CONCLUSION

The pixels which are in the range to detect through the length of contours. Fire was detected by the processorin the image captured by the surveillance camera.

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21. https://gist.github.com/andrew-smith/3856034

AUTHORSPROFILE

R. Sandhiya, Completed under graduate in panimalar institute of technology in the fileld of electronic and communication. My post graduate in college of engineering guindy in the field of medical electronics. My research work in instrumentation and image processing and looking forward to do research activities in various fields of Biomedical technology .Now I am currently working Aarupadei veedu institute of technology.

SanthoshiniArulvallal Mtech Biomedical engineering, Assistant professor, has done publication on topic "sleep apnea detection using smart watch and data analysis using neural network" in a scopus indexed journal, progressing research work in hypertension detection using pulse rate and submitted 3 Research proposals, Once awarded with best paper for the paper "Enhanced security using multimodal meta data Biometric systems".

Lakshmi Shree B, have completed my masters in engineering in biomedical field. Currently working as Assistant Profesor in AVIT college. I have published 1 journal paper in Scopus indexed journal . And 2 research paper proposals are submitted . I am a member of IAENG and looking forward to do research activities in various fields of Biomedical technology.

D. Dhina, Completed under graduate in adiyaman college of engineering hosur and his postgraduate in college of engineering guindy in the field of embedded systems research work in instrumentation and networks.