Fire Detection System using Raspberry Pi

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***Abstract*—Fire presents significant threat to life due to its severe hazards and ability to spread rapidly. Fire detection systems, specially vision-based system offers flame detection prior to any loss or destruction. In this present model, new vision-based device is designed which works on Raspberry Pi and detects flame (visible part of fire) over remote regions. An immediate alert is generated on android application. Here in, HSV color combination is used for proposed model and changes in flame color and texture is studied.**

***Index Terms*—Fire detection, flame color, flame texture, false alarm**

I. Introduction

Fire is a serious threat to life and property worldwide. It is usually caused by combustion of materials which releases heat and light in large amounts. Fire detection systems have been designed to detect fire via sensing different fire related change. Two types of fire detectors have been used so far, namely: traditional/sensor-based and vision-based systems. Former responds against smoke, heat, temperature and pressure, whereas later rely on the light detection. Among the two systems used, traditional detectors have several disadvantages associated with them. These include high cost, slow response time and limited detection range. Additionally, these systems are not feasible as outdoor detectors due to excessive sunlight and wind pressure.

Besides, vision-based detectors can respond flame quickly and can analyzed location of fire. In these detectors, flame which is the vision part of fire can be analyzed via its color, shape and movement based on spectral and spatial models. Although, vision-based detectors have several advantages, however, false detections limit their utilities. Therefore, there is still dire to design new models that are more efficient and can solve problems associated with previously reported models.

The reason behind proposing a system of like fire detection is to prevent from the loss and damages done by fire very before by generating an alert.This research paper consist of six sections.Section I consist of introduction of project, Section II consist of literature survey, Section III consist of related work done for the project, Section IV consist of system model which describes the whole system of the fire detection, Section V methodology behind the proposed system, and Section VI consist of implementation of algorithm.

There aremany fire detection systems are working in different areas in different manners but mostly are sensored based and detect fire through heat and smoke.But the method of fire detection by using sensors ar now not very effective becausce they generate alerts when fire has reached its maximum level which is very dangerous that is why the system is proposed that detects fire in the beginig which is very important to stop it very before so the loss or damages can not be done by it.

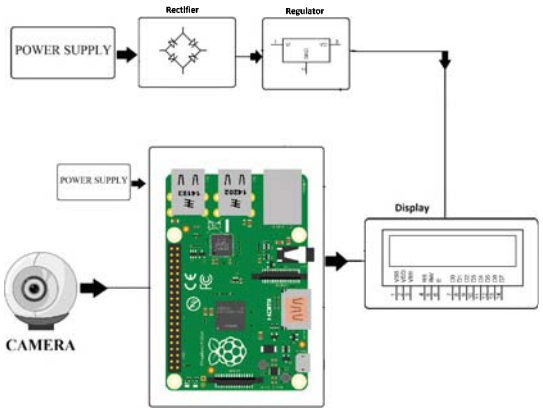

Fig. 1. System Model

II. Literature Survey

A. Motivation

Internet of things (IoT) is the network of programmable software, sensors, electronics and communication facility that helps to gather and transfer data. The objective of the designed system is to alert the remote user while the fire accidents occur. This system can be easily installed at any remote locations

978-1-7281-0447-8/19/$31.00 ©2020 IEEE

from where fire can be easily detected by camera. Therefore, sensors are not required for this purpose. The Raspberry Pi controller processes the camera input and detects fire using heat signatures. By using image processing method, the report is automatically generated and sends to the person immediately after the fire is being detected using Wi-Fi. This interns triggers the emergency mode of system. Advantages including remote monitoring for immediate actions and sending the information at anytime or place, are main attributes of this method.

B. Generate Alert on Fire

The main motive of using this system is to prevent from the loss of life or any other damages to the company or the organization.Few years back the system that were installed are now obsolete because they detect fire or smoke when it reaches the maximum level and until that time the loss was already done. The fire detection system is used to detect fire in air through camera in real time monitoring system based on Raspberry Pi. The main feature of system is to alert generate when fire is started or reached it minimum level to prevent from the loss of lives and damages of any other property or valuable things that are useful for the company or any place where it is installed.

C. Surveillance system

The fire detection system need surveillance to detect the fire and to control it by generating an alert to the registered users on the application. This can be achieved by using Raspberry Pi which control the fire detection s system and the android application is very useful when fire is detected it generate alert and give an alert to fire department. This system works on Raspberry Pi and the Android application. The image processing algorithm is working and it is designed on Python programming language which detects fire and send alert on the server which is connected to android.The android application receives the alert and send notification or generate an alert on the application which can be seen by registered users.

III. Related Work

Some of previously reported fire detection system are based on detecting smoke as a change and then sent response to detector, which rings alarm. Some detectors sense heat as change and after communicating with a detector emergency mode is triggered which ends up in ringing the buzzers. However, after mentioned systems have problems which decrease their importance and open the window to explore new systems. Interestingly, Only few reports are available in literature visual based fire detection system. Most of reported problems are system getting damaged due to heat or wire system get damaged.

A. Shape Representation

System will detect the colors consistent with the basic spectrum factors used in the RGB model, which is based on the Cartesian coordinate system. Initially, videos or images taken by camera are converted from RGB color space to XYZ and then partitioned using an isotropic diffusion segmentation. Later, irregular shapes can be set based on algorithm functions.

B. Color Conversion

In fire detection system each color combination responds 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 images or video captured in the form of framed by the Camera are then converted from RGB to XYZ color space. The color conversion is very important and in fire detection system the RGB model converted into HSV(Hue,Saturation Value) that is very important for the detection of fire on very high scale because it gives the fire detection at very minimum to high scales.

IV. System Model

The purpose is to create a hardware which can detect fire from far away. This device supports the Raspberry Pi platform and android application. Fire is a dangerous thing which can bring a lot of harm to anything. To prevent from loss, sensors are installed but these sensors are not effective. Sometimes they get destroyed by heat or fire or sometimes they generate alert very late until the damage has been done. In contrast Raspberry Pi is very useful because it consumes low power and it is of low cost and it does not need any sensors because the camera will detect the fire and generate the alert immediately to the users or the members of the organization, where this system is installed.

Fig. 2. Raspberry Pi

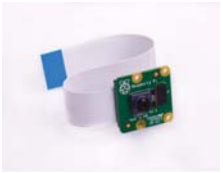

Fig. 3. Pi Camera

V. Methodology

Fire patterns with heat signature are used to detect fire which are color patterns for representing the fire. Following are the three types of filters used to find these signatures:

- RGB filter
- cieLAB filter
- Both
- HSV filter

A. RGB filter

This is used to extract Blue (B), Green (G) and Red (R) component of each pixel. It is necessary for every pixel to verify following conditions:

- If R>G>B
- If R>Rt
  where Rt red threshold value ranging between (0,255). Its value is dependent on light of the image. Rt=5 is used in this method.

B. cieLAB filter

The LAB color model is used cieLAB color model are red, yellow and related colors like orange. For each pixels in this frame the mean value of L, A and Compnents are identified. For each pixel four filters are used.

$$L > L$$

$$A > A$$

$$B > B$$

$$B > A$$

C. HSV filter

HSV is Hue Saturation Value. It uses HSV component and works well in image processing. Using this filter, an object with a specific color can be detected and to reduce the influence of light intensity from the outside.

VI. Implementation of Algorithm

Our implementation of fire detection is used to facilitates the organizations or companies to prevent from the loss of lives and damages of valuable assets. The moment when the fire is detected and to generate an alert on it through mobile application/android application to the users on the application. The algorithm is designed in such a way so that every one can understand it and the android application is also very easy to use. The algorithm is defined below which is very important part of this project or the main part of the project.

- Step 1: Start
- Step 2: Image is captured on real time
- Step 3: Camera captured video continuously on real time
- Step 4: The image frame is acquired from the real time live video feed
- Step 5: Captured image is sent to Raspberry Pi on the real time
- Step 6: Image processing is done on images
- Step 7: If valid ,then go to emergency mode or generate an alert on server
- Step 8: Android Application Start and receives an alert
- Step 9: Send notification message to all user which are registered to Android Application
- Step 10: Stop

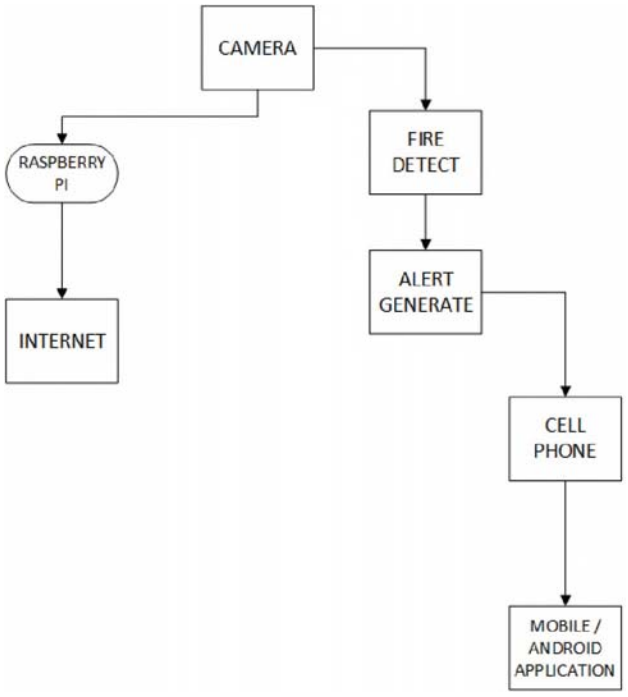

Fig. 4. Flow Chart

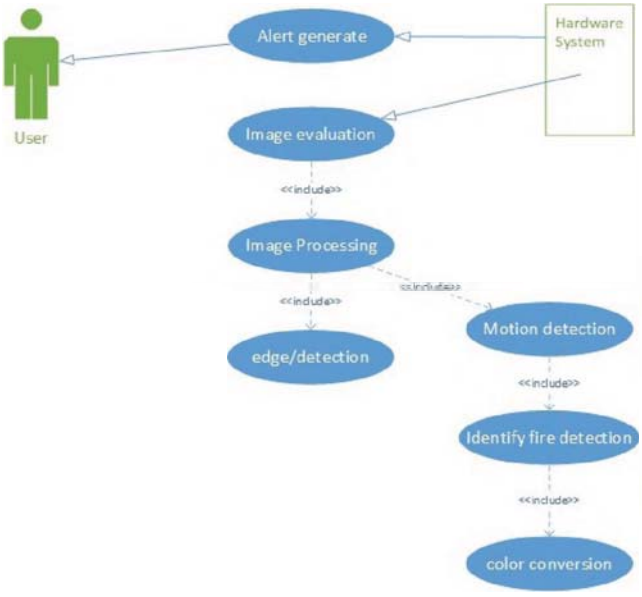

Fig. 5. Use case Diagram

A. Hardware Testing

The hardware testing consist of Raspberry Pi which is controlling the whole system and its very small but fast in processing. Pi Camera is also include in hardware testing.

Fig. 6. Hardware Testing of Raspberry Pi

Algorithm

The image processing algorithm which is working in our project to make our hardware more smart. It also makes our camera more smarter to make visual more accurate.

```
import cv2
import numpy as np
from firebase import firebase
import RPi.GPIO as GPIO
from picamera.array import PiRGBArray
from picamera import PiCamera
import time

def LED_alert(st):
ct = time.time()
if ct < (st + 10):
GPIO.output(7,True)
time.sleep(0.25)
else:
GPIO.output(7,False)
time.sleep(0.25)

#init GPIO
GPIO.setmode(GPIO.BOARD)
GPIO.setup(7, GPIO.OUT)

#init picamera
camera = PiCamera()
camera.resolution = (320, 240)
camera.framerate = 32
rawCapture = PiRGBArray(camera,
size=(320, 240))
time.sleep(0.1)
#fgbg = cv2.BackgroundSubtractorMOG2
(history=1, varThreshold=16,
bShadowDetection=True)

#init firebase App
applink =
'https://firedet-e7f8e.firebaseio.com/'
firebase = firebase.FirebaseApplication
(applink, None)

isFire = False
threshold = 400
start = None
font = cv2.FONT_HERSHEY_SIMPLEX

#fire detection
for frame in camera.capture_continuous
(rawCapture, format="bgr",
use_video_port=True):
image = frame.array
image = np.array(image, dtype=np.uint8)

blur = cv2.GaussianBlur(image, (21,21), 0)
hsv = cv2.cvtColor(blur, cv2.COLOR_BGR2HSV)

#fgmask = fgbg.apply(image)
lower = np.array([1,30,169],
dtype = "uint8")
upper = np.array([36,255,255],
dtype = "uint8")
mask1 = cv2.inRange(hsv,lower,upper)

lower = np.array([30,0,245],
dtype = "uint8")
upper = np.array([180,8,255],
dtype = "uint8")
mask2 = cv2.inRange(hsv,lower,upper)
fmask = cv2.bitwise_or(mask1,mask2)
firecount = cv2.countNonZero(fmask)
output = cv2.bitwise_and(image, image,
mask = fmask)
if isFire:
cv2.putText(image, "Fire detected!",
(10, 230), font, 0.5, (0,0,255), 1)

cv2.imshow("Fire detector", image)
key = cv2.waitKey(1) & 0xFF

rawCapture.truncate(0)

if key == ord("q"):
break

wasFire = isFire
isFire = firecount > threshold

if isFire:
start = time.time()

if start == None: continue
LED_alert(start)

if wasFire != isFire:
firebase.put('fire-state', 'isFire', isFire)
```

```
cv2.destroyAllWindows()
GPIO.cleanup()
```

B. *Software Testing*

The software testing consist of android application working and testing part which is essential and is very useful. Following are the User Interface of android application given down below to understand the android application designing and the use of it.

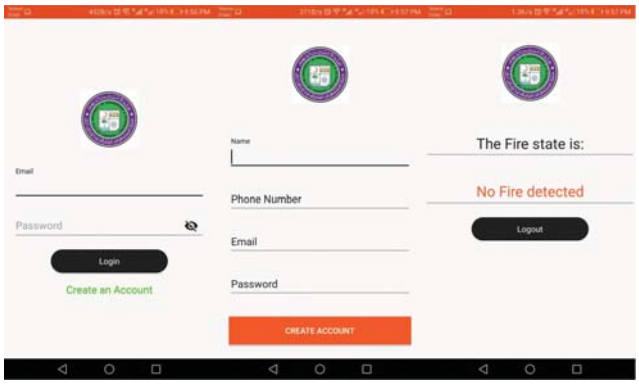

Fig. 7. Android Application

RESULTS

The final result of our fire detection system is that it started detecting fire when fire comes up in front of camera and the system is working correctly and without any delay. But we are still working on the system to overcome the false alerts as the system doesn't know the exact shape and color of fire so its detects the other objects of same color and fire and generate an alert. We are working on our algorithm and making it more efficient so it can detect the exact shape and color of fire and don't get confuse between another shape of other objects and don't generate false alerts.

The fire detection system is very good approach in modern world so that the losses and damages done by fire before will not be repeated again and no other lives will be harm. The main advantage of system is that it is portable and can be carry anywhere but very carefully and is very cost effective and is working very well.

Here is a snapshot of out final working result on andoird application and you can see changing conditions in firebase aswell.

CONCLUSION

Few years back the fire is detected through sensors or any other method or by smoke. But these methods are now old and are not effective because in these methods the fire detects when it reaches maximum level and it was sometimes too late because the damage was already done. To prevent from this and to stop fire when it starts researchers have explored the idea to replace the sensors and to detect fire through internet or by another means that was cheap and useful and beneficial for others.

Fig. 8. Working result of fire detection system

IoT is very useful way to detect fire and to detect fire by using computer vision.The idea is that is to give a camera a power of human eye and to detect fire when it starts but that is not a easy job. The researchers then design and implement different algorithms using programming languages and they come up with a algorithm of fire detection using camera but it has some flaws. The algorithm that are design until now are not able to detect fire completely but they also detect some other objects in the color combination of fire and generate a false alarms or notification. The working on it are still going and researchers are working to minimize the rate of false alarms or notifications.

A fire detection system is proposed using Raspberry Pi connected with a camera and operates via image processing algorithm. This system uses RGB color models to detect fire color and texture. Proposed model works well and we are working on its fire detection algorithm for more effective results and to overcome the problems of false alarms. False alarms are generated sometimes due to objects of orange color and shapes. Consequently, the proposed system will result in the reduction of loss and destruction. In future, this system will help the fire fighters or rescue team to rescue someone immediately and fire fighters will stop the fire immediately by tracing the source or location of fire.

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