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A PROPOSED FIRE DETECTION SURVELLIANCE THROUGH MACHINE LEARNING BASED ON HAAR CASCADE CLASSIFIER

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Abstract

Fire is an unwanted event that could carry a high loss of social wealth and human life. To stop such losses, different alarm systems such as smoke detectors, and temperature sensor-based systems have been developed. Our proposed system is aimed to design and develop a fire detection system that detects fire without any heat or temperature sensor. The primary objective of the fire detection system is to detect a fire early and warn authorities when a fire takes place. The Machine Learning Algorithm has been used to detect the accurate image of fire because it has a prior pattern of fire images already fed into it. On occurring the fire, the camera will send this pattern to Raspberry pi which has already predefined patterns of fire written in the form of an algorithm and afterward will compare it with the new existing fire pattern. When both the pattern matches system will do processing based on the image processing technique. Finally, the system generates a warning message which will be sent on the LCD screen for display, and thereafter the buzzer starts working. The key benefit of this system is it will decrease the risk of losses which occurs mainly due to failure in controlling the fire. The experimental results showed that the designed system can efficiently extract and keep trace of fire pixels in the form of patterns and is worthwhile in providing better output results. This system has compact circuitry and functionality like it is easily implanted in public and commercial places for security and surveillance.

Keywords: Fire Detection, Image processing, Machine Learning, Raspberry pi, alarm, fire.

I. Introduction

Fire is one of the most fateful threats to mankind. A fire outbreak is a misfortune that may cause great loss to human lives as well as can burn and damage the equipment and surroundings where it takes place. Fire detection systems are among the most important components in surveillance systems used to monitor buildings and the environment. As part of an early warning mechanism, the system should have the capacity to report the earliest stage of a fire. Currently, almost all fire detection systems use built-in sensors that depend primarily on the reliability and the positional distribution of the sensors. In a sensor-based fire detection system for an outdoor environment, coverage of large areas is impractical due to the necessity of a regular distribution of sensors nearby.

Due to rapid developments in digital camera technology and video processing techniques, there is a major trend to replace conventional fire detection methods with computer vision-based systems. In general, computer vision-based fire detection systems employ three major stages: fire pixel classification, moving object segmentation, and analysis of the candidate regions. This analysis is usually based on two figures: the shape of the region and the temporal changes of the region. The fire detection performance depends critically on the effectiveness of the fire pixel classifier which generates seed areas that the rest of the system will exercise. The fire pixel classifier is thus required to have a very high detection rate and preferably, a low false alarm rate. There exist few algorithms which directly deal with the fire pixel classification in the literature. We introduce a smart fire detection system based on the machine learning algorithm. The purpose of a fire detection system is to detect early and warn authorities through visual or audio appliances when a fire takes place. For early fire detection, we have used image processing techniques along with raspberry pi which processes the detected fire in real-time and detects fire patterns. Raspberry pi is used because it is an affordable price computer that consumes very little power and can run multiple programs simultaneously. Additionally, it works effectively and does faster processing which helps in real-time fire detection. The circuitry is compact, flexible, and easy to implant anywhere for surveillance. As raspberry pi works as a fire detector, therefore, we do not require any other sensors like the smoke sensor to detect the fire patterns. The major disadvantage of a sensor here in our project is the processing time from sensing fire patterns to execution of alarming the buzzers or text messages on the display. Thus, range and delay can have negative effects on the overall system. The system has eight components including Step-down Transformer, Bridge Rectifier, Filter, Buck Converter, Raspberry Pi, Camera, LCD, and Buzzer. Initially, the transformer will step down the 220V AC to 12V AC. The full-wave bridge rectifier is used to convert AC voltage to DC. But the problem here is Raspberry pi requires 5V DC, to fulfill this requirement, we use a buck converter to step down 12V DC to 5V DC. But before this, it is necessary to get the DC power in pure form. The Diode Bridge gives DC voltage along with some ripples. A low pass filter will remove these ripples. The proposed system comprises three stages: In the first stage, When the system will be in working condition, the camera will record the state of the place through high-quality video (also can capture still images). When a fire happens, the camera will detect this fire and send the pattern of fire to the controller for further processing. The processing involves pattern detection. In the second stage, the fire image pattern is converted into small frames. These frames are compared with the original patterns for which the system is already trained in the raspberry pi module. If the pattern matches the fire, the system will go under emergency mode. In the third stage, after detecting the fire, the system will display a warning message on the LCD screen and it will alarm through a buzzer.

The multitude of components that needed to be researched was the power supply, the type of RC car to be used, and whether or not the RC car is going to be automatically programmed to get a predetermined route or to control it manually through a handheld controller, the GPS unit, LEDs, and types of metal detectors. There are also a handful of other components not mentioned that required as much in-depth research as the main components. With two electrical engineers and one computer engineer, the group will be able to overcome many of the shortfalls that come with a lack of knowledge. Each group member has specific knowledge of specific components that need to be implemented.

When doing research, any average and a regular person can look up particular components and make a respectable machine or robot. What differentiates the engineers from the common hobbyist is the fact we have in-depth knowledge of the material and know the inner workings of the components being placed into the circuit. The engineers know where to look and what to look for rather the average hobbyist just goes to a parts list and regurgitates the schematic or design without putting any of their own imagination and knowledge into the project. With this in mind, the group as a whole is committed to using this design project to fully implement their gathered knowledge over the past four years. This will include intuitive and clever manipulations of current technologies to ensure the best performance of the project.

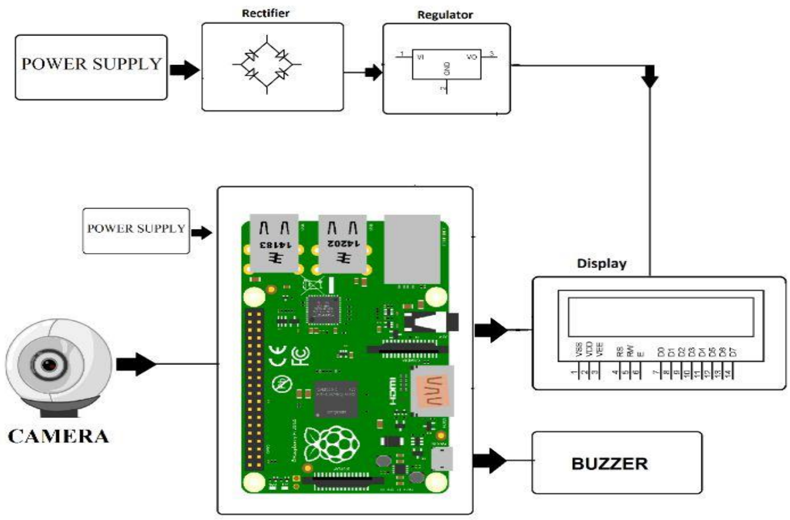

Fig 1. Basic Diagram of Image Processing Based Fire Detection Using Raspberry Pi

II. Related Work

In the paper [I] used the Haar Cascade Classifier Algorithm to try to locate the white blood position in an image.it was found to be capable of locating white blood cells with precision and recall values of 95% and 74%, respectively. The Haar Cascade Classifier Algorithm is also capable of distinguishing white blood cells from other objects of similar colour.

The paper [II] discusses the real-time eye-tracking system using the Haar Cascade Classifier Algorithm. the team wants to calculate the viewing area with the Haar Cascade Classifier Algorithm based on the rectangular features of the human eye. The rectangular eye features are altered to match the representation links where the object is facing. And the results show that the Haar Cascade Classifier Algorithm can verify system performance. Haar Cascade Classifier Algorithm Integrated with Three Additional Categories [III]. In this paper, Li Cuimei and the groups want to discuss Classifier Algorithm once again integrating the algorithm with a new algorithm for three additional sub-categories. Three additional dividers to match the histogram of the first skin, with the second eye detection, and the last oral discovery. Oral detection is used to apply the remaining non-human face and make the false level even lower.

. Nowadays image processing is used in a variety of methods, introducing the application of image processing functionality in the Raspberry Pi. The Raspberry Pi is an initial implanted system and cheap one-board system used to cut the difficulty of real-time applications. This forum is based primarily on python. The Raspberry pi contains a Camera slot Interface (CSI) to connect to the raspberry pi camera. Here, Black, and Low brightness images captured using the Raspberry Pi camera module are enhanced to identify a specific area of the image. This concept is used in the actual use of MAVs, which are mainly used to capture photos and videos with the Raspberry pi camera module; due to the size of the (small) credit card and the small weight of its design. However, an image captured by MAVs will contain unwanted objects due to atmospheric circumstances which is why it is essential to eliminate any noise in the MAV image.

III. Methodology

The system that we have proposed using image processing in fire detection is the ability to assist huge and open spaces and contains three stages: In the primary stage, the camera collects pictures and it transfers them to the controller evaluation. And then the process of further detection has been started. In the second stage, the images are converted into frames, and it will compare those images to already booted images. In the final stage, MMS send to the user.

Fire is sensed using fire patterns with heat Signature. Heat signature is color patterns to characterize the fire. Three filters are used to find the heat signature. They are RGB filter, cieLAB filter, Both, RGB filter 2. RGB filter is used to Extract the Red (R) Green (G) and Blue (B) modules of each pixel. And then in each pixel two conditions are verified. If R >G>B and If R> Rt (Rt is the red threshold value between (0,255). This is based on the light in the image. Here value 125 is used.

We used the LAB color model .cieLAB color model shows red, yellow, and related colors such as orange. For all pixels in the frame, the mean value of L, A, and B components are calculated. For every pixel, four filters are used. If L>L mean, If

A>A mean If B>B mean, If B>A mean whose values run from 0 (black) to 100 (white). The vital vertical axis represents lightness (signified as L*). The color axes are founded on the fact that color can't be both red and green, or both blue and yellow, because these colors face each other. On each axis, the values run from positive to negative. On the-a' axis, positive values show quantities of red while negative values indicate quantities of green. On the b-b' axis, yellow is positive, and blue is negative. For both axes, zero is neutral gray.

The RGB and cieLAB filters are used to accommodate a variety of lighting conditions. It's a fire signature if any of the filters pass a pixel. RGB filter2 (C) Another RGB component-based filter. In night mode, it will perform admirably. The R, G, and B components are compared to threshold values in this method. 140°, 100°, 100°, 100°, 100°, 100°, 100°, 100°, 100°, 100°, 100°, 100°, 100°, 100°, 100 Three conditions must be met:

- R>rt
- G>gt
- B<bt

When it enters emergency mode, it will send the image to the remote user. The ability to serve large and open spaces is a feature of image processing in fire detection. The Raspberry Pi has a higher specification and is less expensive.

Raspberry Pi is a single-board computer with a small footprint. The Raspberry Pi can be used as a minicomputer by connecting peripherals such as a keyboard, mouse, and display. Raspberry Pi is a popular platform for real-time image/video processing, IoT applications, and robotics.

It's similar to a small computer in that it has a CPU, GPU, USB ports, and i/o pins and can be connected to external peripherals to perform a variety of tasks similar to regular computers. The first Raspberry Pi was released in 2012 to make computer learning more accessible to schoolchildren. It is not easy for everyone to learn advanced computer functions at the start of their computer learning process. This tiny computer was created so that everyone could get a glimpse of some of the basic functions that an advanced computer can perform. Let's take a look at the Raspberry Pi 3's features one by one.

The Raspberry Pi 3 is a small single-board computer developed by the Raspberry Pi Foundation that includes a CPU, GPU, USB ports, and i/o pins and can perform basic computer functions. This tiny computer was created to simplify the computer learning process so that even the most inexperienced student can benefit from it and anticipate what a more advanced computer can do.

In 2012, the Raspberry Pi 1 (first generation Model B) was released, and it quickly gained a reputation for ease of use and availability. Similarly, the Raspberry Pi 2 was released in February 2015 with a slight design improvement and more RAM than its predecessor. The Raspberry Pi 3 Model B was released in 2016 and features a quad-core processor that provides 10 times the performance of the Raspberry Pi 1. And the Raspberry Pi 3 has an 80 percent faster speed than the Raspberry Pi 2.

The Raspberry hardware has undergone several changes in terms of peripheral device support and memory capacity. Every new addition comes with a minor design improvement and the addition of advanced features to the device, such as the Raspberry Pi 3 Model B+, which is the most recent version of Raspberry Pi 3 that exhibits all of the specifications introduced in the Pi 3 Model B, with the addition of Network boot, USB boot, and Power over Ethernet, making the device useful in hard-to-reach places.

The system will be built with an image processing-based fire detection system, as well as the Raspberry Pi and IoT. This programme employs the Haar Classifier Cascade Algorithm. Figure 2 depicts the procedure.

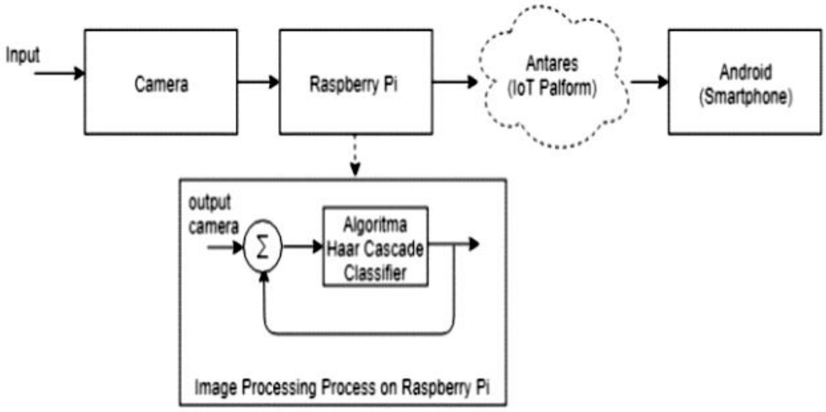

Fig 2. Image processing-based fire detection using raspberry pie

In this system, the camera serves as a Catcher, and it will later serve as the Raspberry Pi's image input (input). The Raspberry Pi 3 Model B, which will serve as the system's brain, was used. All image data will be stored in sports on the Raspberry Pi 3 Model B using the Haar Classifier Cascade algorithm. The image data from the Raspberry Pi 3 Model B will then be sent to the server as string data in the form of a warning (alert), in this case using the platform server. Antares is an IoT platform that sends server-side data warnings (alerts) and displays them on the user's smartphone..

IV. Flowchart System

Figure 3 depicts the flowchart system used in this study. First, the camera is turned on and displays the entire state of the room. The image from the camera will be processed in the Raspberry Pi using the Haar Cascade Classifier Algorithm, and if the image is of a fire, the system will recognize the fire and send the string data to the server, as well as to the user (smartphone) for notification.

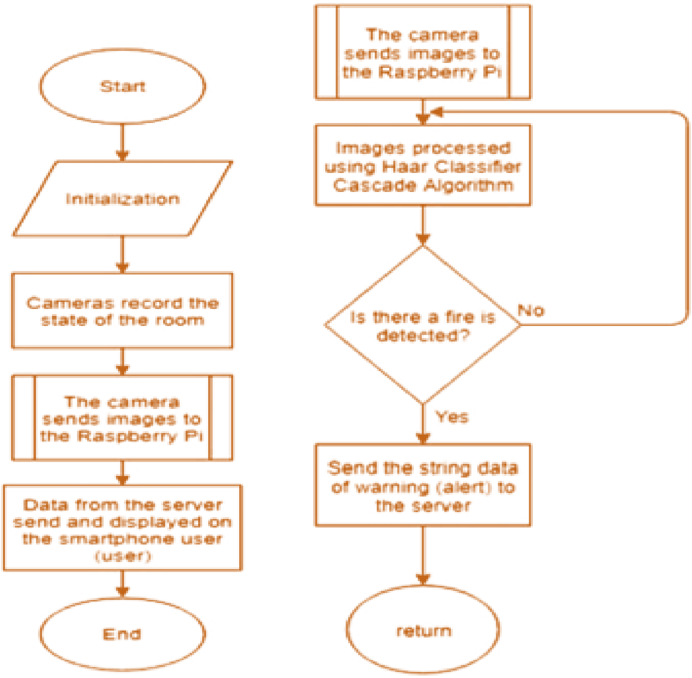

Fig 3. Flow chart of the proposed system

A few things, such as image processing, image models, and RGB [IV], can be used in the image processing method to obtain information about the object. Image processing is a type of signal processing that takes an image as an input and transforms it into another image as an output using various techniques. There are techniques and processes in image processing to reduce or eliminate the effects of image degradation, such as image repair or enhancement (image enhancement), image restoration (image restoration), and special transformation, as well as other subjects of digital image processing such as image encoding, image segmentation (image segmentation), representation, and the task image (image representation and description).

An illustration of a model image is discrete image coordinate conversion in Fig 4.

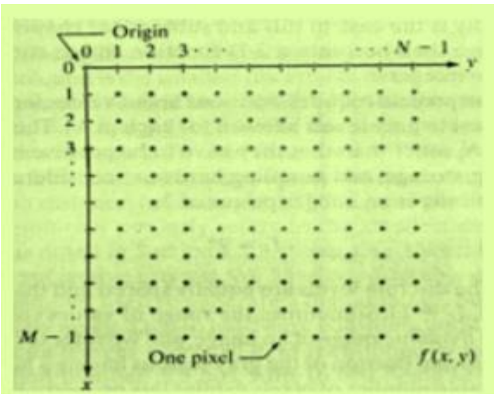

Fig 4. Image Matrix Representation

Reflected light from everyday objects is used to create the image. The function f (x, y) can be written as a function with two elements: the magnitude of the light source that complements our view of objects (illumination), which can be written as I (x, y), and the quantity of light reflected by an object in our view (reflectance component), which can be written r (x, y).

$$f(x,y)=i(x,y)r(x,y)$$
$$0 < I(x,y) < \infty$$
$$0 < r(x,y) < 1$$

According to the above equation, the value of the reflected is limited by the values 0 (total absorption) and 1 (total reflectance) of the function f (x, y) coordinate special good discrete, as well as the brightness level. A digital image (next will be abbreviated with image) can be thought of as a matrix with MxN rows and columns, yielding the dots in equation 2.

$$f(x,y) = \begin{vmatrix} f(0,0) & f(0,1) & f(0,N-1) \\ f(1,0) & f(1,1) & f(1,N-1) \\ f(M-1,0) & f(M-1,1) & f(M-1,N-1) \end{vmatrix}$$

In RGB, the colour white is created by combining (tristimulus) the three primary colours with values of RN = GN = BN = 1. The combined value of the three colours is shown in the table below for some of the major colours of the NTSC [V] colour coordinates. The Tristimulus Color Diagram of the System Krominan and the main recipient of NTSC is depicted in Figure 5 below.

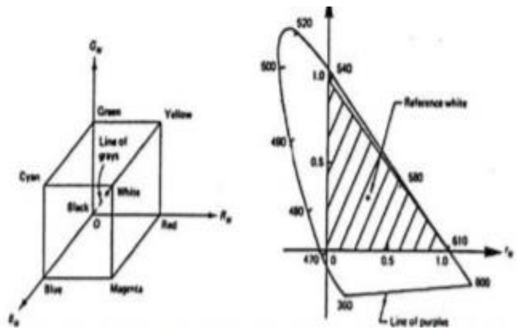

Fig 5. Tribulus color diagram of the system Krominan and the receiver main

Aside from the RGB method, image processing can also be done using the HSV colour space (Hue, Saturation, Value) method [VI]. To begin, hue (H) is a colour classification system (e.g., red, green, or yellow). The hue is represented, as well as the angle's degree, which ranges from 0 to 360 degrees (although for some applications the normalized from 0 percent to 100 percent). Second, the distance from the light black-and-white axis is represented by Saturation (S). The percentage ranges from 0 to 100 percent. The last is Value (V), which is represented as black and white on the shaft height. The range of possible distance values is 0 percent to 100 percent. A value of 0 indicates that the colour is always black. 100 can be white depending on the saturation.

The Algorithm in this project that we used is Haar Cascade Classifier, which is a method for detecting objects in an image, and the Haar Cascade Classifier method was developed by Viola-Jones. This method is based on Haar-like features that are strengthened when combined with the classifier cascade. Haar-like features are widely used in object detection because they provide a quick extraction process and can represent a lower resolution image. This method has been used successfully in a variety of object detection applications. The classifier is usually trained using some examples of simple and positive examples of negative images that are all the same size. The area has 1 Classifier for rated similar to the object.

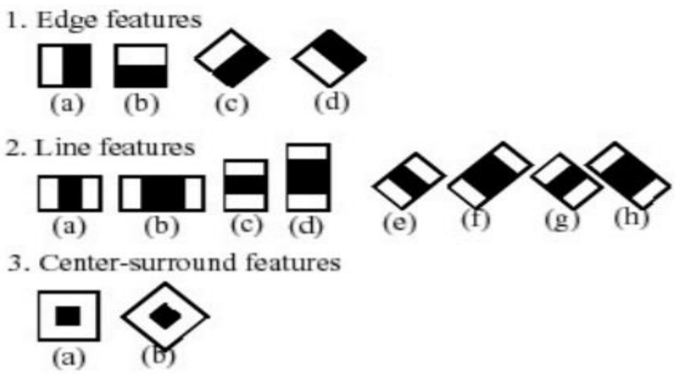

Fig 6. Haar-like features representation

V. Results and Discussion

First of all, our system takes input from a Raspberry pi camera module. The fire video frames will be converted into the form of fire image frames. These frames of fire images will do processing using the image processing technique. Video is recorded for a duration of 4 seconds and then the processing happens. The total time taken to process the data is merely four seconds and if a fire is detected an alert is issued. This process keeps going on in an endless loop. The outcome and testing were performed at a distance of 50 centimeters. The first test is performed at a distance of 50 centimeters. In this test, we used the light intensity and the distance of the fire from the camera to determine the system's accuracy. The results of the test, as shown in the table below, show that the accuracy varies depending on the level of light intensity.

Table 1: Results at 50 centimeters

Distance	Light	Fake Fire	Real Fire	Accuracy
50 cm	64 lx	8	1	12.50%
	56 1x	6	1	16.70%
	36 1x	3	1	33.30%
	28 1x	2	1	50%
	0 1x	1	1	100%

VI. Conclusion

We have proposed a compact and smart fire detector that works on image processing technology based on the machine learning algorithm to obtain the warning in real-time. The system has included three stages: - Firstly, the camera will capture the fire image, and send it to the controller to do the processing. Secondly, the fire image will be converted into fire patterns which are afterward compared with the original image which is already programmed in the raspberry pi. In the last stage, on detecting fire the system will display a warning message on the LCD screen and the buzzer sounds an alarm. The main objective of writing this paper was to build an efficient and flexible surveillance system having the ability to detect a fire early and easy to implant in the public as well as commercial places. Furthermore, the circuitry used is in low quantity which saves cost and makes the system optimum as compared to other devices like sensors. The algorithm gives the best output results when a fire occurs. We implement the algorithm to detect the fire and then it will send the image to the remote user. In the form of enhanced an image in different enhancement degrees using raspberry pi. It was found that the algorithm developed for raspberry pi was executed successfully. We can conclude that distance has no bearing on the level of accuracy, so the accuracy measurement values will be the same no matter where the fire position is measured. While the intensity of the light has a significant impact on measurement accuracy, the brighter the light, the lower the value of measurement accuracy obtained.

In the future, we make our system smarter and more efficient by implementing a GSM Module that identifies the exact location of the fire incident. This module eliminates the risks of danger for example if god forbid the buzzer stops working. It will warn authorities through an alert message on their mobile. Furthermore, we also transform our system to IoT based on which all networking devices will be connected.

Conflicts of Interest:

There is no conflict of interest regarding the paper.

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