

## Indoor Fire Detection Using Raspberry Pi and IoT-Based Smart Alert System for Real-Time Safety and Emergency Response Applications

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### ABSTRACT

Unexpected fire, at times, is dangerous and cause loss of people and property. Live inspection by video surveillance cameras and fire detection by image processing using Open CV and Raspberry Pi is a novel and efficient method. A vision based system is adopted to increase the detection rate and lower the fault alert rate. Levels of flame-high or low, are identified by edge detection techniques using different experts by combining factors like color, shape and motion of the fire. GSM technology is incorporated which helps to share the location information to the nearest fire station. The microcontroller functions to activate the fire alarm as well as the exact sprinkler rather than activating all of them to suppress the fire.

**KEYWORDS:** Flame detection, Raspberry Pi, Image processing, Alerting and suppression system.

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### 1. INTRODUCTION

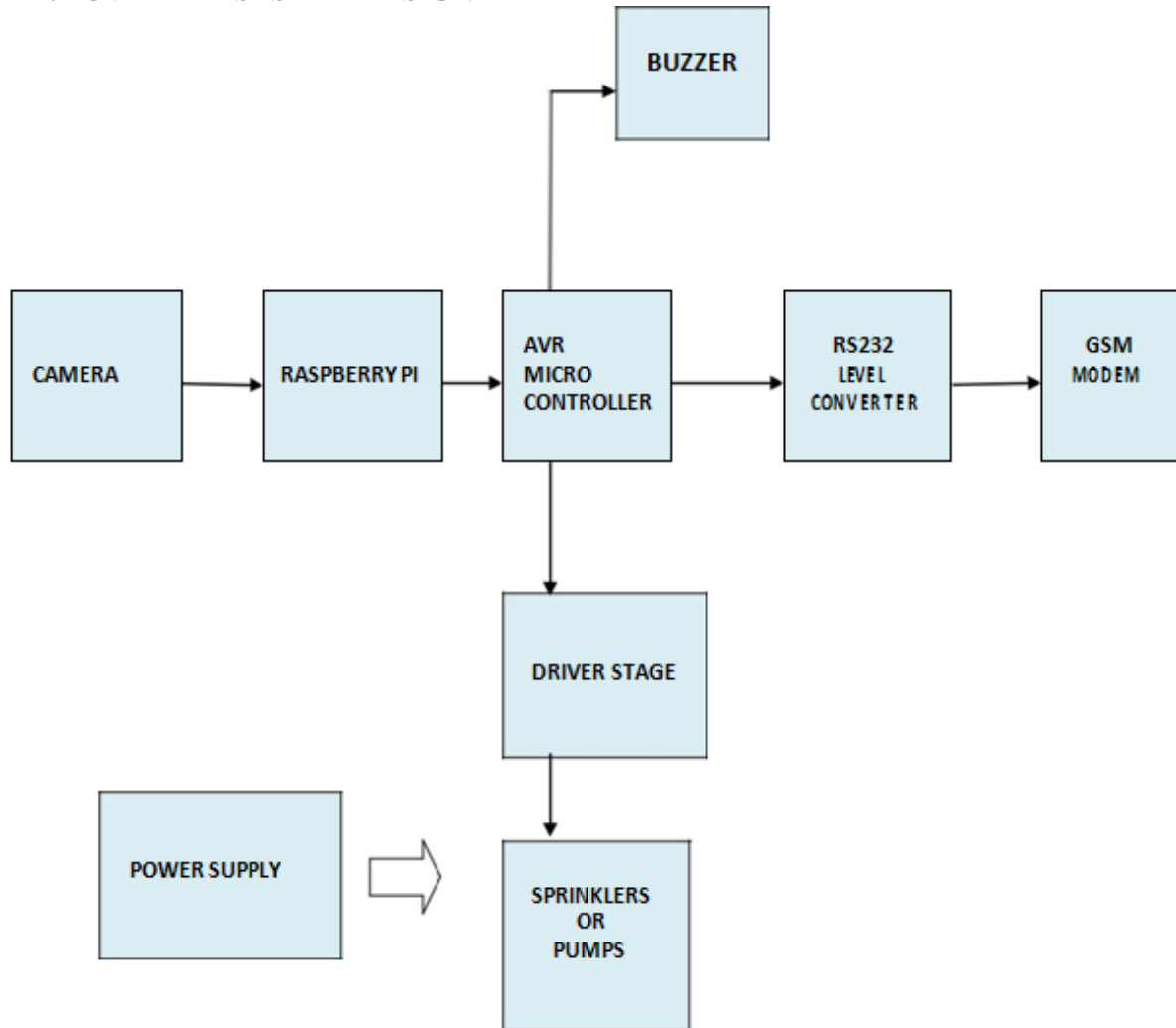
Nowadays, indoor rooms face challenges in developing fire emergency in a timely manner and alert the building occupants and the emergency organizations. Inefficient and conventional methods are the cause of late detection of fire. Different types of sensors are being used as options in many of these applications. These sensor-based method depends on the various characteristics of fire like smoke, heat, radiation, etc., which are generally detected based on the presence of certain particles produced by fire photometry rather than combustion itself. Fire alarm systems with sensors is not the best option because of its time delay as well as insufficient information regarding the exact location or size of the fire. A vision based smoke and fire detection employing raspberry pi is a very novel idea and efficient way in overcoming the challenges faced in this scenario. Live video surveillance takes the advantage that false alarms which are caused by some colored objects or by other means can be prevented, as it provide the ability to monitor large open spaces. A vision based fire detection system using either image or video, itself has various benefits like [6]:

- low cost, as CCTV cameras are already being installed in almost every infrastructure.
- wider area monitoring: Rather than a point sensor, webcam functions as a volume sensor.
- quick response time for flame detection, and many more.

Already there exists several papers that deals with the fire detection – alarm process, for which the tools used for processing differs even though the main ideology remains the same. MATLAB is an important tool used for these image processing methods, but it can be replaced by some other platform like open CV as it's processing speed is less and is very expensive, though it is easy to use. Open CV is better than MATLAB from an application point of view [2].

The proposed paper consists mainly of two stages: A webcam or CCTV which capture the video or image and send it to the AVR microcontroller comes under the first stage. The second stage includes AVR controlling both alerting and suppression modules at the same time. Water sprinklers, buzzers and GSM modems are employed for this stage.

## 2. OVERALL SYSTEM DESIGN



*Fig 1: Block diagram of the proposed system*

The system mainly deals with the real time detection, alerting and suppression of fire in indoor scenarios by recording the video inside the room through the surveillance camera installed. The major technique used for this purpose is image processing and the software used is open CV in raspberry pi for the detection.

The fire is detected in a specified manner by making use of its color, shape and motion. Alerting is done through the GSM technologies where the location information is shared to the nearest fire station. On the other hand, suppression part is done by the microcontroller. The microcontroller is programmed in such a manner that it activates the buzzer as well as the fire sprinkler exactly where the fire occurs. This system makes use of the following elements:

- Webcam: The primary component and input to the system, used for capturing the video in real time. The major advantage is that it monitors the fire accidents over wide area and it is of lower cost. It can easily be implanted.
- Raspberry pi: Here, we use raspberry pi model B+ that incorporates a number of enhancements and new features. Improved power consumption, increased connectivity and greater IO are among the improvements to this powerful, small, light-weight ARM based computer. Using Embedded C, it is programmed for the detection of fire.
- Microcontroller: The output signal from the raspberry pi is given to the microcontroller which functions to activate the sprinkler and the buzzer also an Alerting via GSM module to the nearest fire station. Here we are using an AVR microcontroller which is ATmega328.
- Buzzer: To detect the audio alert from the microcontroller, a buzzer is used .It will also be helpful to inform the people about the fire accident .It is of lower cost and easy to implement in the system.

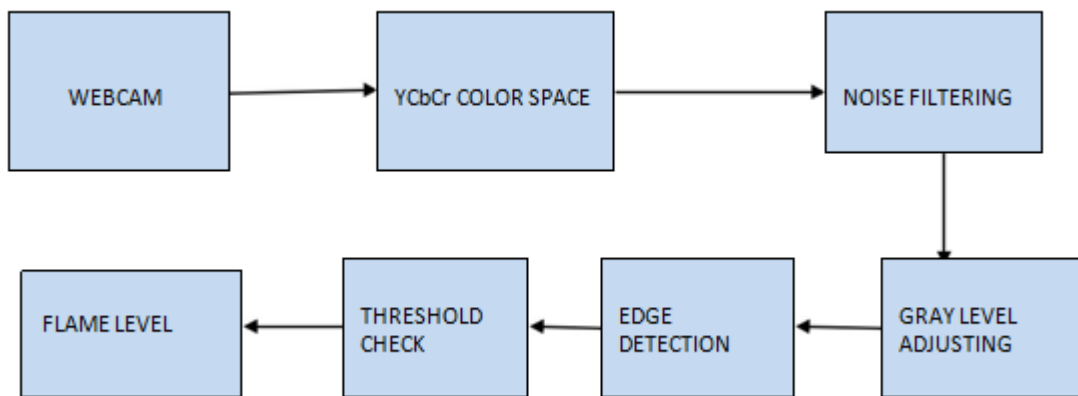
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- RS232 level converter: Max232 IC is used here mainly for interfacing the network. For the conversion of the voltage level, this stage is used. It converts the signal from the rs232 serial port to the proper signal which is used in the TTL compatible digital logic circuits. This IC consists of 16 pins. It controls the GSM module using AT commands.
- GSM: Global system for mobile communication to determine the precise location. GSM is used to send and receive data from a central unit through a data call. SIM 900 is used for this purpose.
- Power supply: A common power supply is given to the circuit which goes to every stage in the system. Mains powered power supply is utilized to lower the cost. A regulated 5V supply is generated.

- **Real Time Visual Detection Of Fire**

In order to improve the detection of fire in real time and manage false alarm a vision based fire detection system is necessary. It acts as a standalone system.

The block diagram depicts the fire detection system.



*Fig 2: Block Diagram Of Fire Detection*

A video surveillance camera is used for fire detection using images and videos taken by it. Image processing is the technique which is used to break the video frame by frame and operations are made on them to extract information. The flame features are studied and using edge detection and threshold values, fire is detected, thereby establishing a fire detection model. Initially, MATLAB is used as a tool for processing. Though it is easy to use, it takes more time for processing and is expensive. And from an application point of view, Open CV is better than MATLAB[6]. Hence, it is replaced by Open CV. Color models like HSV, YCbCr are used in the system for more effective detection. The system detects whether it is high level or low level flame thereby activating all sprinklers or the nearest sprinkler to fire respectively. The anti-noise performance is very strong and accurate for the proposed detection system.

- **Alerting System**

Immediately after the fire is detected by the video acquired by the webcam, an SMS alert is given to the nearest fire station by means of a GSM modem[1], which is directed by an AVR microcontroller. It will also alert the people in that particular area and send a short duration of the live video to the security of the building. The procedure is as follows:

The image or live video captured by the webcam is manipulated using Raspberry pi through some detection techniques from where the signal is given to the microcontroller, which will make an SMS or call to the already saved number[2]. In this way the alerting system works. For the transmission and reception of the data, a GSM modem is used. SIM 800/SIM 900 is a quad band GSM module that works on frequencies GSM 850 MHz, EGSM 900MHz, i.e., it works on different frequencies. Here, this GSM modem is connected to the microcontroller using an RS232 level converter. This is an interfacing stage used for the conversion of voltage level. It is provided by MAX232 IC which converts the signals from the RS232 serial port for the proper signal, used in the TTL compatible digital logic circuits. SIM 800 consumes less current and it saves power. It is 1.2mA in sleep mode and the power is 3.4 to 4.4V

### 3. SUPPRESSION SYSTEM

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Fire suppression systems are used to extinguish or prevent the spread of fire in a building. They use a combination of dry chemicals and/or wet agents to suppress fire. Fire sprinklers use water to extinguish and control fire. Microcontroller is programmed to activate the exact sprinkler where the fire occur. By detecting the level of flame, the sprinkler near to the fire activates depending on the level of flame -high or low, rather than activation of all of them .

MOSFETs can be used for motor control applications which is the driving stage of suppression module , sprinkler as well as the buzzer alarm .Here, switching action is controlled by either a half-bridge control circuit which uses two MOSFETs, which is simple or by a full- bridge control circuit using four MOSFETs. Movement of DC motors and even stepper motors can be controlled using Power MOSFETs by employing the techniques like pulse width modulation (PWM). These systems are under the control of AVR , which provides six PWM pins for this function .MOSFETs are biased in such a way that they alter between cut-off and saturation states to perform its function as switches . This is because there is no current flow through the device in saturation region and there is a constant amount of current flowing through the device in saturation region, mimicking the behavior of an open and closed switch, respectively .MOSFETs offer higher switching rates when compared to bipolar junction transistors.

## 4. CONCLUSION

Accidents due to undetected fire have caused great cost to the world. The need for efficient fire detection system is rising. Existing fire, smoke detectors are failing because of the inefficiency of the system. A vision based system with the video surveillance fire detection system is proposed to have high detection rate and low fault alert rate[5]. Therefore it is essential to design and implement an effective algorithm to be embedded into the existing video surveillance systems for early fire detection[4]. In this paper, we proposed a fire detection system using an ensemble of experts based on the information about color, shape, and flame movement. The paper also introduces an alerting and suppression system.

Image processing by edge detection is the approach used to detect fire in the proposed paper. A surveillance camera is used for fire detection using images and videos taken by it. Detection is followed by a system for alerting and suppression. Suppression system activates fire sprinkler by accessing its QR code.This can even be done by accessing the webcam ID . Alerting is done with the help of GSM modem which sends an emergency message to the nearby fire station and other emergency organizations . Future works can be focused on extending the satellite imaging system to detect the forest fire as well as a number of cameras can be connected to a common Raspberry pi for detection of fire in various places of the same building[2].

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