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Raspberry Pi-Based Smart Home Smoke Alert

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***Abstract*:** Everyone desires a safe and comfortable existence amidst the hustle and bustle of modern life. The usage of home automation allows for the remote control of various appliances in the home. If you want to protect your home from intruders and fires, installing a security system is a smart idea. Therefore, this paper proposes a home smart smoke alert for a real-time monitoring system that, in the event of a fire, detects the presence of smoke in the air as a result of the fire and records smoke voltages via a smoke sensor put inside each room. The Raspberry Pi was one of the embedded systems utilized to create this home-smart smoke alert system. The system's capacity to remotely send an alert when smoke is detected is its primary feature. The system will send a warning email to the designated recipient with location details when smoke is detected. The user can quickly verify the incident by clicking on the email's link to their home's CCTV. After confirmation, the user can use Short Message Service (SMS) or Direct Call to inform the firefighter of the incident (999). Utilizing this approach will lessen the likelihood of false alerts being reported to firefighters. This solution can add safety measures to Smart Home systems and stop any big fire-related incidents from happening.

***Keywords*:** Smart smoke alert, raspberry Pi, smart home, gas sensor (MQ-4), Pi-based, CCTV.

1. Introduction

A subset of ubiquitous computing known as "smart houses" involves integrating technology into buildings for the sake of energy efficiency, comfort, healthcare, security, and safety [1–3]. A higher quality of life is provided via automated appliance control and supportive services in smart homes [4]. The goal of this research study is to develop Home Smart Smoke Alert while concentrating on home safety [5, 6]. Any fire disruption or fire accident incidence begins with smoke as a primary symptom. Early fire detection will help you save your house. A fire is an unwelcome occurrence that could result in a significant loss of social wealth and human lives [7, 8].

Different alarm systems, including temperature sensor-based systems, fire detectors, and others have been created to stop these losses [9–11]. Different automatic smoke alarm systems are now accessible as a result of technological advancements and the lowering cost of instrumentation like temperature sensors and cameras, among others [12–14]. Along with the more affordable instruments, internet-based and wireless broadband technologies have advanced, and there are now numerous systems that enable low-cost, high-speed data transfer and wireless networking [15–17].

Numerous automated and monitoring systems with low power consumption, quicker processing, and lower costs have been made possible by the affordable single-board computer the size of a credit card, such as the Raspberry Pi [18–22]. The home smart smoke alert system that is suggested in this study combines the use of accessible tools with connectivity and wireless communication. The purpose of this article is to do research on smoke detection at a specific location in the home, alert or tell the owner promptly, and provide details for their response.

The rest of this paper is organized as follows. Section 2 reviews the existing works. Section 3 shows the proposed Home Smart Smoke Alert. Section 4 describes the work process of our proposal. Section 5 shows the experiment testing and results. Section 6 and Section 7 show the discussion and conclusion of this paper, respectively.

2. Related Work

Using the Raspberry Pi and Arduino Uno, this section examines several smoke and fire detection techniques. Additionally, talk about the efficient method the alert processing system processed the user.

Md Saifudaullah Bin Bahrudin et al. propose a real-time monitoring system in [23] that can detect smoke from a fire in the air and take pictures using a camera that is installed within a room when a fire starts. The Raspberry Pi and Arduino Uno were the embedded systems utilized to create this fire alarm system. The system's capacity to remotely send an alert when a fire is discovered is its major feature. The system will show a web page with an image of the room's condition when a fire is detected. To use Short Message Service to notify the firefighter of the event, the system will require user confirmation (SMS). Due to network latency, image processing requires a lot of power and storage, and there is a high risk of failure. The verification process on the webpage requires user access, which could delay the firefighter reporting process.

The implementation of an embedded system for monitoring wireless sensor nodes and cameras deployed inside a building for security surveillance is covered in [24] by author V. Rakesh et. al. The system's main components are remote fire alerting and intruder detection [25]. When smoke or intruder movement is detected, the system activates the alarm, begins real-time video recording for a certain amount of time, and sends warning messages via Short Message Service (SMS) to mobile devices. An FTP (File Transfer Protocol) web server receives the recorded video clip and immediately uploads it there so that it can be downloaded later from any location in the world. This method's drawback is that it does nothing to put out the fire.

The proposed method to warn the remote user while fire mishaps occur using the camera to detect the fire is discussed in [26] by author R.Dhanujalakshmi et. al. The Raspberry Pi controller interprets the data from the camera and uses heat signatures to identify fire. When a fire is detected in any area of the frame using image processing, a report is automatically generated and sent to the person using Wi-Fi or GSM. The system will switch to emergency mode when it detects a fire. This system's shortcomings include message veracity and lateness. It can be too late for the user to take action because the camera detects fire based on heat signatures and alerts based on heat. Additionally, this type of advanced camera will cost far more than a standard one. Most studies concentrate on alerting based on fire detection [27]. Any disturbance caused by a fire or fire accident immediately manifests as smoke. This study was done in order to warn users about smoke detention rather than fire detection. sending the user an email with specific information about the smoke detection's location.

3. Proposed System

The creation of the smoke and temperature sensor research case is the primary emphasis of this project. The microcontroller continuously receives analogue data packets from both sensors. The information is processed and converted to ppm and Celsius. The Raspbian programming shows the data that is being translated. When sensors go beyond the predetermined limit, they wirelessly transmit an alert via email to the email address specified in the source code. The project's methodology outlines the steps that were taken to complete it. The SnO2 fire sensing materials utilized by the MQ-4 sensor are less conductive in clear air and the conductivity of the sensor would increase the smoke concentration. The sensor can translate different conductivities into the output signal for the matching smoke concentration. The MQ-4 smoke sensor has an extremely high sensitivity to smoke.

3.1 FlowChart of Proposed System

As shown in Figure 1, the flowchart of the proposed system in the smart home.

3.2 Schematic Diagram

Figure 2 presents a schematic diagram of our proposed system.

3.3 Image View

Figure 3 presents an image view of our proposed system.

3.4 Hardware and Software

The focus of this subsection is on the numerous parts and elements that were employed in the project. These consist of:

- Python Programming

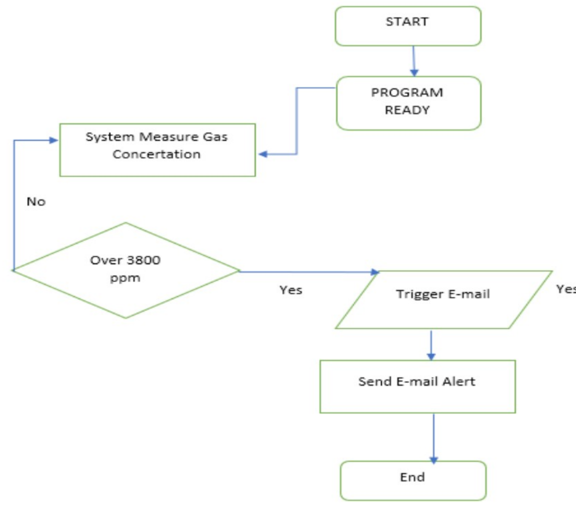

Figure 1. Flowchart Proposed System

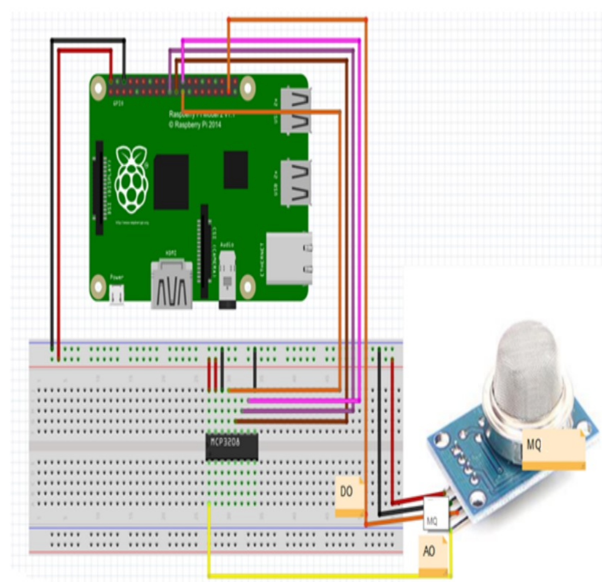

Figure 2. Schematic Diagram

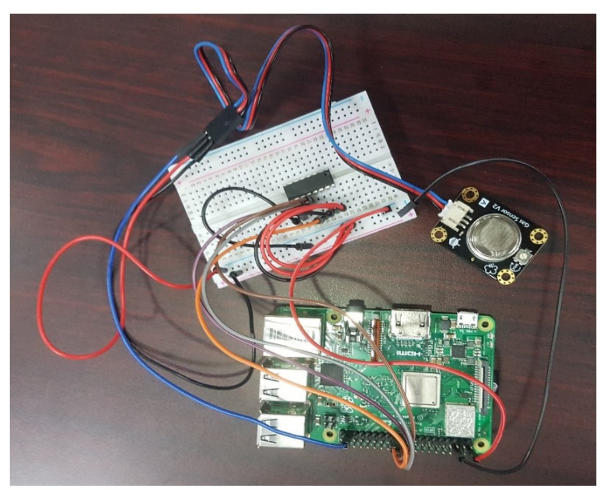

Figure 3. Image View

- Raspberry Pi 3

- MQ4 smoke sensor
- Analog to digital convertor (ADC) x1

4. Work Process

We will construct an MQ4 that analyses smoke for this project. We also require an Analog-Digital Converter in addition to a portion of the sensor. We employ an MCP3008 as well as a 3.3- and 5-volt logic converter. We can see how to link the Raspberry GPIO to the sensor from the schematic diagram. And let's say we have a working Raspbian operating system on the software front. A mixture of microscopic liquid, solid, and gas particles makes up smoke. Although smoke can contain a wide variety of chemicals and gases, the majority of what is visible smoke is carbon (soot), tar, oils, and ash. As a result, in this project, the MQ4 gas sensor is being used as a smoke sensor. The method of identifying potentially dangerous smoke escapes from sensors is known as smoke leakage detection. In most cases, these sensors use an audible buzzer to notify individuals when a hazardous chemical has been detected [28, 29]. The gas sensors (MQ4) that connect to the Raspberry Pi can be used to find this. The raspberry pi receives a voltage as input whenever the sensor detects the presence of gas. The number of sensors that are affected by the leakage is displayed on a virtual display to demonstrate the leakage. IoT sends this information to the email (Gmail). By running a Python script and installing the necessary sensor libraries, the entire system operates.

4.1 Raspberry Pi

The third version of Raspberry Pi is the Raspberry Pi 3 model B. There are numerous applications for this potent single-board computer that is the size of a credit card. You get a more potent CPU with the popular Raspberry Pi board format, which is 10 times quicker than the model from the beginning. For particular designs, it also includes wireless LAN and Bluetooth connectivity. The Raspberry Pi has a Broadcom Chip (SoC) system with an on-chip graphics processor and an ARM-compatible central processing unit (CPU) (GPU). The power range is between 1,5w and 6,5w, and the data is stored in micro SDHC cards. The Raspberry Pi is configured to choose the Noobs package of the Raspbian OS.

4.2 Gas Sensor (MQ-4)

Ammonia gas, hydrogen sulfide, and steam from the benzene family, as well as other dangerous gases, are especially susceptible to the MQ-4 gas sensor. It is a low-cost sensor for various applications and is capable of detecting harmful gases. It offers advantages including a lengthy lifespan, low cost, and simplicity of operation, as well as good sensitivity to harmful gas across a broad range. There are many MQ-4 gas sensors. used in industrial gas alarms, portable gas detectors, and alarms for household gas. SnO2ha was used to make the MQ-4 gas sensor.

4.3 Analog to Digital Converter (ADC)

Analog to Digital Converter samples the analogue signal at the falling or rising edge of each sample clock. The ADC receives, measures, and transforms the analogue signal into a digital value once each cycle. The ADC transforms the output data into a series of digital numbers by estimating the signal with set precision.

4.4 Python Programming

Python is an effective programming language that is also incredibly simple to utilize with the Raspberry Pi. Even when compared to C or C++, it utilizes significantly fewer lines of code. Using Python, we may connect to the Raspberry Pi 3 in our project.

5. Experimental Test and Results

5.1 Testing Process

After the predetermined start time of the 20s, there is no signal output. After a 20-second preheating period, the sensor would output once the data had stabilized. It is typical for the sensor to remain slightly warm. Smoke can be produced by it using a lighter. The voltage value and the text "WARNING SMOKE ALERT" signal output turn on when a light is shone in front of the sensor. An email alert is wirelessly sent whenever the sensors go beyond the limit set using the email address specified in the source code.

5.2 Results

The following outcomes were attained following simulation using MobaExtreme software. Since the smoke sensor outputs an analogue voltage, the input of the microcontroller that was intended to be linked to the sensor was used to simulate it with the proper voltage. Table 1 shows a summary of attack detection mechanisms.

The 3800ppm essential smoke detection value. It had a predetermined value that could be altered in the code. The visual alarm was activated and delivered to the e-mail address when it was determined from the simulated results that the smoke quantity quickly exceeded the pre-set value of 3800 ppm. From the observations, the system is able to perform the functions of a smoke-detecting device. As shown below, the email warning will appear. The user can check on the camera by clicking on the IP address of the camera, and it will display the location details of any smoke detected and potentially dangerous fire areas.

6. Discussion

The goal of this research is to warn the user in advance if a fire-related unexpected incident occurs. In addition, the householder is usually away at work and occasionally the kids are left alone at home. The goal of this research is to improve the safety features of smart homes. When we talk about a "smart house," we typically think of wealthy individuals, luxurious homes, and implementation costs that are considerable. The goal of this research is to warn the user in advance if a fire-related unexpected incident occurs. In addition, the householder is usually away at work and occasionally the kids are left alone at home. The goal of this research is to improve the safety features of smart homes.

Table 1. Summary of Attack Detection Mechanisms.

Sensor Input	Sensor output	Alert display
0.00V	0ppm	Safe zone, Smoke-Free QTY=0ppm
0.50V	1020ppm	Safe zone, Smoke-Free QTY=1020ppm
1.00V	2050ppm	Safe zone, Smoke-Free QTY=2050ppm
1.50V	3070ppm	Safe zone, Smoke-Free QTY=3070ppm
1.70V	3480ppm	Safe zone, Smoke-Free QTY=3480ppm
1.80V	3690ppm	Safe zone, Smoke-Free QTY=3690ppm
1.84V	3770ppm	Safe zone, Smoke-Free QTY=3770ppm
1.86V	3810ppm	WARNING SMOKE ALERT QTY=3810ppm email sent
1.90V	3890ppm	WARNING SMOKE ALERT QTY=3890ppm email sent
2.00V	4100ppm	WARNING SMOKE ALERT QTY=4100ppm email sent
2.50V	5120ppm	WARNING SMOKE ALERT QTY=5120ppm email sent
3.00V	6140ppm	WARNING SMOKE ALERT QTY=6140ppm email sent
3.50V	7170ppm	WARNING SMOKE ALERT QTY=7170ppm email sent
4.00V	8190ppm	WARNING SMOKE ALERT QTY=8190ppm email sent
4.50V	9220ppm	WARNING SMOKE ALERT QTY=9220ppm email sent

When we talk about a "smart house," we typically think of wealthy individuals, luxurious homes, and implementation costs that are considerable.

7. Conclusion and Future works

In this paper, we discussed the most current development that can lessen tragic fire accidents. Additionally, we discussed the creation of a Smoke Detector and Raspberry Pi-based Home Smart Smoke Alert system. The research is more fruitful and valuable as a result of the advancements in IOT and sensor technology. Our suggested smoke alert system makes use of effective smoke-detecting methods and equipment. The prototype needs to be built so that it can be determined whether or not a smoke truly happened. The system will send an email with location information and a link to the CCTV system to warn and trigger the user. Users can see the CCTV Camera to verify by clicking. As a result, false alarms will be reduced. All users of the proposed system will be able to afford it and can employ low-cost, dependable equipment.

In future work, we extend this work by automatically using image processing on CCTV camera images after sensor detection to cover false detection.

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