iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** VIII **Month of publication:** August 2020

DOI: https://doi.org/10.22214/ijraset.2020.30868

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VIII Aug 2020- Available at www.ijraset.com

A Survey on Indoor Air Quality and Hazard Detection System

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Abstract: ***To ensure the safety of people from hazardous events that might happen in their houses and the surrounding environment. In this project, some sensors are used to detect various hazards like fire outbreak, LPG Leakage, increase in gas toxicity and alert the corresponding public about the cause at the time of the event so that he/she could take precautionary measures. It also informs the respective safety department which takes action of such events for public welfare.***
Keywords: VOC (Volatile organic compound); IAQ (Indoor air Quality);

I. INTRODUCTION

Indoor air pollution is regularly ranked among the top five health risks of the world .A normal individual spends almost about 90% of his time indoor due to which indoor air decline in indoor air quality can pose great risk on his health.CO(carbon monoxide),CO2(carbon dioxide) cause major human performance like Tight Building Syndrome(TBS) a chronic disease which hinders human performance which has no singular cause and respiratory problems, Methane, Butane , LPG and smoke are some of the common flammable gases when leaked cause accidents [1]. Furthermore improper ventilation leads to increase or decrease in oxygen leading to high concentration of Carbon dioxide or Carbon monoxide.

In Cities due to industrialization all the buildings and especially industrial areas should take care of the air quality where the presence of the harmful gases like Sulfur Dioxide ,CFC(Chlorofluorocarbon), VOC(Volatile Organic Compounds) might cause adverse effect on public health if not taken care of immediately. The public comes in contact with most of the time [2].Indoor Air Quality (IAQ). In some solids or liquids, volatile organic compounds (VOCs) are emitted as gases. VOCs include a variety of chemical substances, some of which may have adverse health effects in the short and long term. Most VOC levels are consistently higher indoors than outdoors (up to 10 times higher). A wide range of goods numbered in the thousands emit VOCs.

For household products, natural chemicals are commonly used as ingredients. Many commonly used items such as paints, wax, washing ingredients, beauty ingredients and varnishes contains organic solvents. Because many people spend a lot of their time indoors, long-term indoor exposure to VOCs can contribute to serious health problems.

Through this project, the levels of VOC using a USB sensor dongle and detect the LPG, CO and Smoke concentration (ppm) indoor. For the purpose of the measurement of VOC levels MQ2, MQ5, MQ7 can be used. These sensors are connected to a single board computer such as Raspberry Pi which performs the computation and store the data into a time series database Influx DB and use the Grafana application to quickly build an air-quality monitoring dash board and detect hazards using image processing.

A. Hazard Detection System

A gas sensor could be a device that, often as a part of a security system, detects the presence of gases in a part. This sort of apparatus will be required to detect gas leaks or other emissions and may interface with an impression system to automatically finish off a process. This sort of device is very important because there are many gasses that may be harmful to organic life, like humans or animals. This kind of device is widely employed in industries and might be found in locations like on oil rigs and might be employed in firefighting and various hazards

II. LITERATURE SURVEY

The Indoor Air Quality monitoring system which detects quality of air in indoor helps in detecting and improving air quality and to be cautious about personal health but this system would cost more. In[1] this paper they are trying to present a low cost air quality monitoring system with wireless technology using components like Arduino, XBee, micro Gas sensors this system collects 6 parameters of Air quality from different locations at the same time. The performance of this presentation is measured by comparing it with the professional air quality monitoring system. In [2] this paper their objective is to design an autonomous system which can detect Carbon Monoxide (CO), smoke and other harmful gases other than these, gasses like Liquid petroleum Gas (LPG), methane and propane are also detected.

Also high temperature are sensed and displayed via an LCD panel also an alarm is connected to alert people in case of critical situations. They have used components like PIC microcontroller, gas sensors like MQ4 and MQ7. In [3] this paper the level of volatile organic compounds (VOC) are detected based on the high frequency of Solid Mounted Resonator (SMR), here two SMR devices which are in used in these system are driven by a pierce oscillator, this system will be having two modes. The active resonator is polymer spray coated and are simulated with non-coated resonator synchronously for precise calculation of IAQ,
It has the capacity to detect the concentration of toluene down to 5ppm. It has a good sensitivity of 60Hz/ppm for 180nm PDMS polymer coated SMR resonator at 900MH. .In [4] this paper they discuss about importance of health and safety concerns based on indoor air quality (IAQ) their work is about real-time detection of Carbon Dioxide concentration by using wireless sensors network system in indoor also the users are alerted in time to time, They have used Metal Oxide Semiconductor (MOS), electro chemical and optical sensors, CO2 sensors like IAQ2000, OPM15 Relay Node and programmable microcontroller PIC18. There are many obstacles in implementing professional level Air Quality System, Some like high cost implementation of air quality monitoring system which are not practically feasible and also positioning of standard monitoring system in unnecessary places. Through [5] this paper they are proposing movable intelligent air quality monitoring system which is cost effective also solves the above problems related to standard monitoring system, The Data collected through this system is compared to a professional system to get the statistics. They have used Arduino autonomous movable module, MQ7 CO sensor, DH722 temperature and humidity sensor and SharpPM2.5 optical dust sensor which are sensitive to airborne particles. Gas leakage and explosion has become one of major household and industry disasters, this occurs due to leakage in pipes and vents where human reachability is impossible such that maintenance becomes harder.[6] This paper solves the issue by using autonomous robot which can avoid obstacles.
By ultrasonic sensor along with an infrared sensor, these sensor have two modes which are obstacle avoiding mode and line following mode by using such modes and sensors it can navigate through tunnel and vents. It also has been coupled with a gas sensor MQ2, CO detection sensor to detect source of leakage and concentration of LPG, CO and smoke. Once certain limit of IAQ has crossed it alerts the user via a wireless network. They have used TCRT5000 IR sensor LM358 op amp compactor, MQ2 CO gas sensor, HC-05 Bluetooth module. In Regular RGB vision based model we have seen the system fails to produce accurate results and are always slow at processing and alerting the users. Here in [7] this paper they have implemented a centroid variety of fire in consecutive frames technology. At first they use RGB-HSI color model which outputs red and saturation readings then centroid is applied which is average coordinate of pixels in a region by using area tracking algorithms for frames of video. It calculates centroid values and are compared with ROC values as a threshold based on which the user is alerted. In this [8] paper they have proposed a method for detecting fire by using neural net and deep learning technologies. Here the camera records images and sends to a Convolutional Neural Network (CNN) model which classifies them into three different states like fire, smoke and neutral. Since the neural net is trained to classify input images from the camera to appropriate states, the datasets of the CNN consisting and of housing, high-rise and forest fires of which quarter of them are trained rest as test set. They have used AlexNet, GoogleNet and VGG16 technologies for their CNN. In this[9] paper by the use of Internet of Things(IOT) and sensors they identify Indoor Air Quality (IAQ) in a way that they have proposed a system by using BME680 sensor of bosch as a humidity and barometric pressure sensor,SGP30 a computerized multi pixel gas sensor, CCS811 a low powered gas sensor which has Metal Oxide(MO) for enhance and accurate reading of Volatile Organic Compound(VOC) detection ,along with UV sensor and a LORA based ARDUINO for calculating the Indoor Air Quality levels. By using this across many gateways the user can analyze accurate IAQ readings in indoor. In this[10] paper they have proposed a system for detecting combustible gases by the use of embedded technology, signal processing , digital circuitry to create an intelligent combustible gas detection system the gases like LPG, Methane, Butane etc. This system can be modified into detecting any particular combustible gases detection system as per the need. This paper focuses mainly on detection, anti-interference and compensation. They use Catalytic Combustion resistance sensor (CCR) for detecting the gases. Once detected it is then digitalized to electric signals and amplified, then these values are compared with a set of security values (safety values). If it exceeds the values, the MCU generates Alarm signals and the user is notified by buzzer and LCD display. The sensor values are shown on LCD. They have used STC89C52 Micro Controller (MCU), DS1820 temperature sensor and catalytic combustion resistance gas sensor

A. Proposed System

In this project, we will be building Indoor air quality and Hazard detection system by using various sensors. We will use Raspberry Pi SBC, MQ2 Gas sensor, Raspberry Pi Cam V2 and uThing: VOC sensor to detect toxic gases and hazards. These components provide IAQ data, MQ2 data and images which are processed by Raspberry pi. Images are processed by image processing model called COCO_SSD_QUANTIZED.

The processed data of IAQ and MQ2 are sent to GRAFANA API through Influx database for user to check the real time condition. Whenever the data crosses over certain PPM threshold, Twilio and SendGrid are used to send messages, emails and grafana alerts slack messages. Whenever the CSQ model detects fire it will give an alarm to the users and surroundings.

B. Components Used

The system is divided into several different functional modules which are used to detect Indoor Air Quality (IAQ) Readings and CO, smoke reading from MQ2 and uThing:VOC sensors, Fire Image Detection from Raspberry Pi Cam V2 which then sent to INFLUX-DB and grafana API which then based on the readings if in case the readings crossed threshold it notifies by alarm and messages, And uses IR sensor to control the ventilation based on the temperature , fire and Gas Readings.

1) Raspberry pi 4 B

Fig: Raspberry pi 4 B

Raspberry Pi 4 B is a recent item in the well-known Raspberry Pi. It offers very good speed up, mixed media execution, memory, and network contrasted with the earlier age Raspberry Pi 3 Model B+. The proposed system uses raspberry pi 4 model B. It is cost effective, credit card sized computer that connects to a computer monitor or a TV and uses a standard mouse and keyboard. Raspberry pi 4 is the fourth generation Raspberry pi which replaced raspberry pi to model B. It is a 4 core ARM Cortex-A72 processor clocked at 1.5 GHz. It has 2 GB LPDDR4 SDRAM. Once the boot completes the raspberry pi is connected to the internet for obtaining the IP address. IP address is obtained using the command “ifconfig”. In the raspi-configurations camera module, IAQ and gas sensors and the VNC server is enabled for future connections. This processor is used to process the data read by different modules which are in JSON format, to process image received from PI CAMERA and store the data in a time-series database (Influx-DB).

2) uThing: VOC sensor

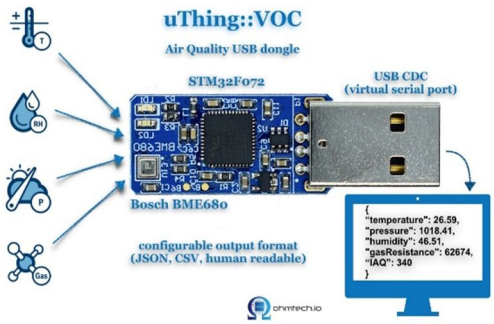

Fig: uThing: VOC sensor

This component is used to measure ambient temperature, humidity, barometric pressure and VOC gas. It has integrated Bosch Sensortec BME680 sensor. Using BSEC (Bosch Sensortec Environmental Cluster) fusion library this component gives precise calculation of ambient air temperature outside the device, ambient relative humidity outside the device, pressure outside the device, air quality (IAQ) level outside the device. It gives configurable output formats like JSON, CSV through command line. It takes power input of 5V from USB port, 25 mA. It has IAQ range between 0-500, temperature resolution of 0.01 °C, absolute temperature accuracy at 25 °C: ±0.5 °C, humidity accuracy tolerance of ±3% r.H. It has operating range between -40 to +85 °C, 10–90 %r .H, 300–1100 hPa. It has humidity resolution of 0.008% r .H and data rate configurable between 3 seconds and 1 hour.

3) MQ2 Gas Sensor

Fig: MQ2 Gas sensor

MQ2 Gas Sensor is used to detect LPG, Alcohol, Propane, Hydrogen, CO, smoke and even methane. It has an electrochemical sensor, which changes its resistance with different concentrations of gasses. The sensor is connected nonparallel with a resistance to make a resistance circuit, and therefore the resistance is employed to alter sensitivity. When one amongst the above gaseous elements comes connected with the sensor after heating, the sensor's resistance change. The change within the resistance changes the voltage across the sensor, and this voltage are often read by a microcontroller. The voltage value are often used to find the resistance of the sensor by knowing the reference voltage and therefore the other resistor's resistance. The sensor has different sensitivity for various forms of gasses.

4) PI Cam V2

Fig: PI NoIR Camera V2

Raspberry pi NoIR camera v2 module is used for video broadcasting. It is connected to the Raspberry Pi' through a CSI bus. It has a fixed lens and provides high quality image. It is of 8mp native resolution. This sensor is capable of capturing 3280x2464 pixel static images and it supports 1080p 30, 720p 60 and 640X480p 90. Pi camera is connected to the Raspberry Pi 4B board and powered up. It is then enabled on Raspberry Pi GUI.

5) IR sensors and Buzzers

Fig: Buzzer module

Buzzer is used alert the user through sound.

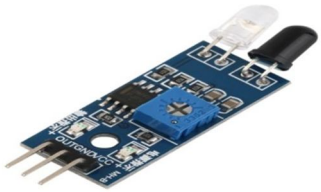

Fig: IR sensor

It is a module which detect the presence of objects before them and can also be used as a remote controller for ventilators, AC's, Extinguishers etc.

III. CONCLUSION

In the future many people will be spending a lot of our time indoors for working, leisure etc. In order to make people lives easier and risk free about indoor safety, they can make use of IOT enabled products like ours to give a better representation of the health risks and other happenings on the indoors all within the comfort of an app in their smartphones along with a tiny device to save many lives.

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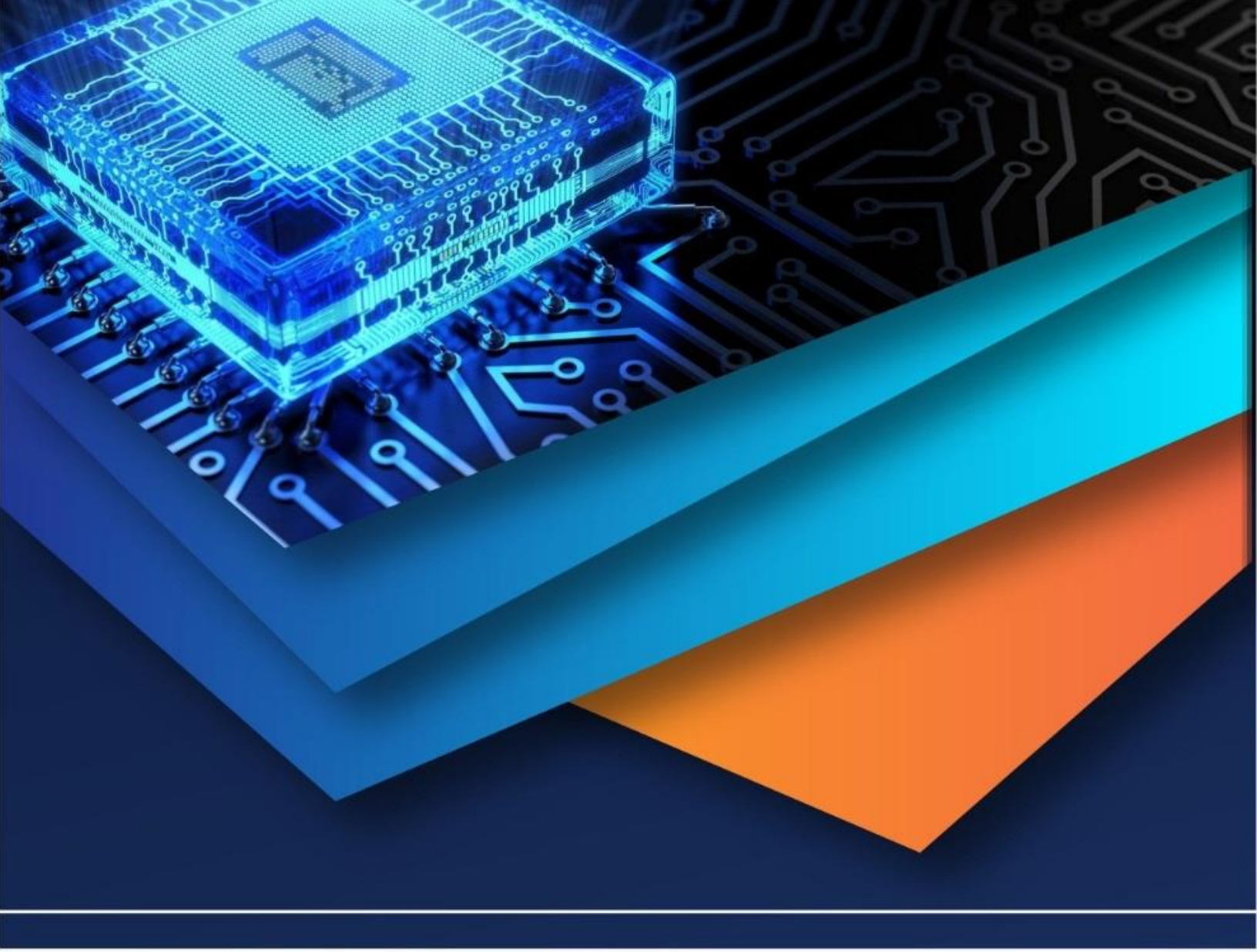

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