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Hospital Fire detection and Alarm System Using Arduino with Temperature & Gas Sensors

for

ECE3502 IOT Domain Analyst

Project report, Winter Semester - 2020-21

by

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1 Abstract

Fire detection and alert system is very important in Industries, Shops, Malls, big apartments/buildings, parking areas, Chemical Factories, Educational institutes. etc. We can detect fire/temperature or smoke at an early stage and send fire alert message to the fire control center. This can help us to take actions at early stage and saving lives & properties from damage. Commercial Fire detecting systems usually have an alarm signaling, with the help of a buzzer or Siren. Here we are going to design an IOT based Fire Alerting System using Temperature and a smoke sensor which would not only signal the presence of fire in a particular are but will also send a data and related information through IOT platform, then to email.

***Key words**: buzzer, IOT, Fire Alerting System*

1.1Objective

- ✓ To design and implement a low power source fire alarm system.
- ✓ To send live information of fire information to the particular control point using IOT Platforms
- ✓ To add automatic door opening system when temperature & smock values exceed the fixed threshold.
- ✓ To give sound signals to the nearby people.
- ✓ To analyse temperature and smock data values, get some prediction to know after what time will it be saver. Or out of human control.

1.2 Problem statement

Design buzzer, temperature sensor, and gas sensor-based fire alarm system using tinker cad and thing speak. Analyse the data using Jupiter note book.

1.3 platform and software used: tinker cad, thing speak, jupyter note book.

2 Literature Review

2.1 Design of Fire Detection and Alarm System Based on Intelligent Neural Network

It is published by Mingyi Zhu….et..al, in 13 March 2011. For fire detection and alarm system with simple function, positioning difficulties, false positive and false negative in traditional intelligent building, the fire detection and alarm systems based on intelligent neural network have been designed. It can do integrated estimation with a variety of fire detection information detected by the microcontroller, neural network intelligent algorithm was joined in the software design, MATLAB simulation realize multiple synchronous intelligent detection, which

effectively detect various types of early fire and reduce the fire. Intelligent fire detector system has the ability of self-learning and adapting. It can automatically adjust the operating parameters according to the actual environment. Thus, it can enhance the accuracy of alarm. Usually there are three ways to achieve: intelligent Controller, intelligent detector, and intelligent distribution. The fire detection and alarm system based on neural network intelligent algorithm is that it can detect fire more accurately and reduce the false alarm. It combines the multiple detection and intelligence detection together, realizing the fire detection and alarm system high intelligence, high reliability and versatility, which provide new ideas and workable solutions for the fire forecasting and early warning.

2.2 An Automatic Fire Detection and Warning System Under Home Video Surveillance

It is published by Md. Mahamudul Hasan, M. Abdur Razzak in 21 July 2016. In this paper, an automatic fire detection and warning system under home video surveillance is presented in order to identify fire from video camera data and warn the concerned people accordingly. The planned system undergoes a low computational time taking fire detection approach using RGB colour space, and it warns the people dynamically than conventional alarming unit. The designed system will be able to cope up with the present conventional fire detection approach under security surveillance system. The used fire detection approach has been tested under different scenarios is also presented to substantiate the accuracy of the system. An automatic fire detection and warning system has been designed using video camera. The system can detect fire from the knowledge of physical fire behaviour and warn people automatically before getting into hazardous state. The system alerts registered people primarily by sending SMS; it also sends SMS notification to fire station automatically based on situation demand. The system has been tested under different resolution colour images, so it can give the ability to run with different types of video camera. The system's warning unit what uses microcontroller unit also leaves the space for adaptability with conventional systems.

2.3 Design and Implementation of Fire Alarm Device Based on Single chip

It is published by Shan Chen..et.al, in 14 July 2019 . Fire is the most common and frequent occurrence of these hazards. Therefore, this paper designs and implements a fire alarm device based on single chip. When a fire occurs, a large number of smokes and higher temperatures will be generated. The device can detect smoke signals and temperature signals through smoke sensor detection module and temperature sensor detection module, and send them to single chip to decide whether to alarm. In the specific implementation process, it is divided into two

parts: The first part is the hardware design, including single chip module, sensor module, display module, alarm module and key module. The second part is the software design, which uses C language to develop the alarm system through Keil uVision 4 software. At the same time, in order to make it more convenient for users to use, emergency alarm key and threshold adjustment key are designed, which can realize emergency alarm function and threshold parameter present function. The experimental results show that the device has stable structure, good performance and practical value. Based on single chip, this paper completed the design and implementation of the fire alarm device, and achieved the expected design requirements, that is, when the red indicator light is on and the buzzer sounds, the temperature exceeds the predetermined threshold; when the yellow indicator light is on and the buzzer sounds, the smoke concentration exceeds the predetermined threshold; when the emergency alarm key is pressed, the indicator light is on and the buzzer sounds, and the alarm parameters and emergency alarm can be set through the corresponding key control. Through experimental tests, the device can complete the detection of normal temperature and smoke concentration, and make judgment according to present threshold values. Once the alarm condition is reached, the device will give an alarm immediately.

2.4 Design and Realization of Fire Alarm System Based on CAN Bus

It is published by Chen Yueping….et.al, in 22 October 2017. CAN bus is one kind of serial communication bus which support distributed control and real time control effectively. In this paper, an intelligent fire alarm system based on CAN fieldbus technology and multi-single-chip-computer communication system is introduced. CAN (controller area network) is a fast serial bus that is designed to provide an efficient, reliable and economical link between fire detect sensors and fire control actuator. By use of the new technology of CAN fieldbus and single-chip-computer technology, Hardware circuit and software design for intelligent node SJA1000 based on CAN and fire detector are given. The designs of structure for network, parameter assignments for network and communication protocols are described in detail. CAN bus is regarded more and more by people because of unique design thought, predominant performance and sky-scraping reliability of CAN bus. CAN bus is forced to develop and apply thanks to establishing CAN international standard. Error and miss alarm rate is reduced greatly. Difficult problem which is error and miss alarm is solved because that intelligent fire alarm and monitoring system based on CAN bus is applied in modern times. The fire alarm and monitoring system is used to enhance veracity and reliability of system. In the application, based on the demand of practice, number of intelligent nodes of CAN bus is chose. And so fire

protection design is made more safety, economy and reasonable. Proposes fire alarm and monitoring system is applied in the practice. Perfect control effect is achieved.

2.5 Design Wireless Multi-Sensor Fire Detection and Alarm System Based on ARM

It is published by Haibing Hu…. et.al, in 02 October 2015. The system uses nRF2401 for short-range wireless communications, GPRS for long-distance wireless communications, ARM9 for center console, Wireless Multi-sensor Fire Detector for node, and BP algorithm is used for judging the probability of fire. Wireless Multi-sensor Fire Detector is formed of the low-power electrochemical carbon monoxide sensor, photoelectric smoke detector and semiconductor temperature sensor. BP algorithm program is embedded in the S3C2440A ARM. The samples of BP algorithm were derived from the fire detection standard room of the State Key Laboratory of Fire Science of China. Center console uses Em GIS (embedded GIS) to show where the fire breaks out and uses GPRS to transmit SMS to the fire command center. The system is low false alarm rate, low cost, fast response and convenient to install. This system use ARM9 board for the center console, use nRF2401 module for wireless communication, use GPRS module for remote alarm. Develop Em GIS software for this System specifically, which not only can shows the location of the fire broke out, but also can control the GPRS remote alarm module. Compared with traditional fire detection alarm system, the system saves a lot cost of hardware and improves the efficiency of the fire detection alarm. It not only can make up for the limitations of wired fire detection system, when use in ancient buildings, temples, museums, etc., but also in family homes, villas, etc., the system will has wide applicable market and prospects.

3 Introduction

It has been found in a survey that 80% of losses caused due to fire would have been avoided if the fire was detected immediately.

In this project, we have built a fire alarm using Arduino Uno which is interfaced with a temperature sensor, a smoke sensor, and buzzer. The temperature sensor senses the heat and smoke sensor senses any smoke generated due to burning or fire. Buzzer connected to Arduino gives us an alarm indication. Whenever fire triggered, it burns objects nearby and produces smoke. A fire alarm can also be triggered due to small smoke from candlelight or oil lamps used in a household. Also, whenever heat intensity is high then also the alarm goes on. Buzzer or alarm is turned off whenever the

temperature goes to normal room temperature and smoke level reduces. We have also interfaced LCD display .

Arduino fire alarm system is an important system for industrial purposes as well as for household purposes. Whenever it detects fire or smoke then it instantly alerts the user about the fire through the esp8266. For this purpose, we are using Arduino Uno which is from the Arduino family. Also, the Arduino interfacing with an LCD display is done to display the status of the system whether the Smoke and Overheat are detected or not. And Arduino interfacing with the esp866 is done so that the user gets an alert message. It intimates the user about fire detection. This system is really useful whenever the user is not in the house or industry or inside the premises. Whenever a fire occurs, the system automatically senses and alerts the user by sending an alert to an email on a user's Android mobile.

4 Design :

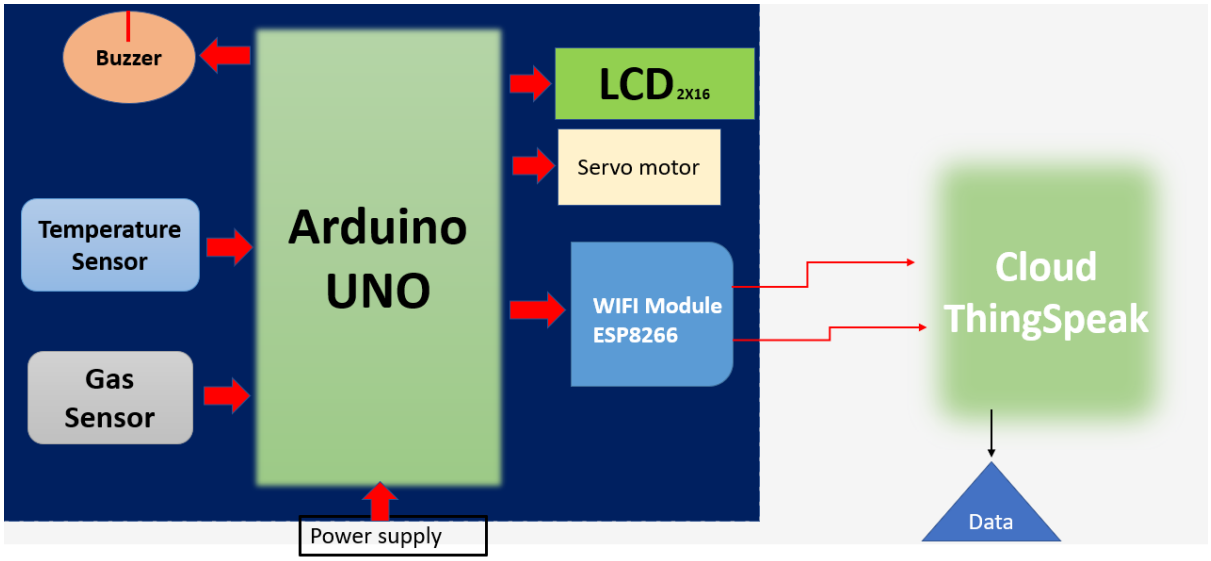

Fig 1: Block diagram for fire alarm system

4.1 Procedure for the design

System design: for the system design we used thinker Cade circuits and thing speak as a cloud. We send the data form two sensors output (Temperature and gas sensor) data to the thing speak cloud using EPS8688 Wi-Fi module.

Data: our sensor data store in cloud data storage plat form. We downloaded the data form thing speak cloud as excel file .csv format.

Data computation: for data computation and pre-processing we used Jupiter note book, Spyder IDE using python code. Using these data, we computed corelation between the gas and temperature data using heatmap corelation technique. We design a multiple linear regression model and we tested the accuracy using R^2 accuracy test method.

4.2 Component description :

I, Arduino UNO Board.

is a microcontroller that is used to accept inputs from sensors connected and provide an output action on the desired device connected to it. The sensor inputs can be from smoke sensor, temperature sensors, etc. The output from this device can be received through other output devices such as LED, Buzzer, Serial monitor, etc.

ii LM-35 Temperature Sensor

gives an analog output based on the instantaneous temperature value. This analog output is proportional to the instantaneous input

iii Gas sensor

is used to measure the concentration or presence of gas in the atmosphere. It is also used to detect smoke in the air. Based on the gas, a potential difference is generated by changing the resistance of the material present inside the sensor. The output is measure in terms of Voltage.

Iv Resistors

Resistors are passive devices that restrict the flow of current or divide the voltage through the circuit. The input power passes through these resistors and then to the sensors to avoid damage.

V breadboard

It is the basic component of any circuit building process. All components, be it input sensors or output display devices are connected to the power supply, microcontroller using wired connections through a breadboard. The holes in the breadboard are in series. There are various sizes like full-sized, half-sized, and mini breadboard

Vi led

Light Emitting Diode is a commonly used light source. It is a semiconductor that emits light when current flows through it.

Vii buzzer

It is an electrical component that generates a beep sound on receiving an input. It works on the principle of piezo crystal.

Viii Servomotor:

It used as door in this project, when the fire is exist , the door will be automatically , open , and allow people to leave.

Viiii esp8266: for sending the data from tinker cad to thing speak.

4.3 System design

The system circuit consist of buzzer, resistor, esp8266 wifi module, gas sensor , temperature sensor, potentiometer, lcd, servomotor, light emitting diode ,Arduino uno and bread board

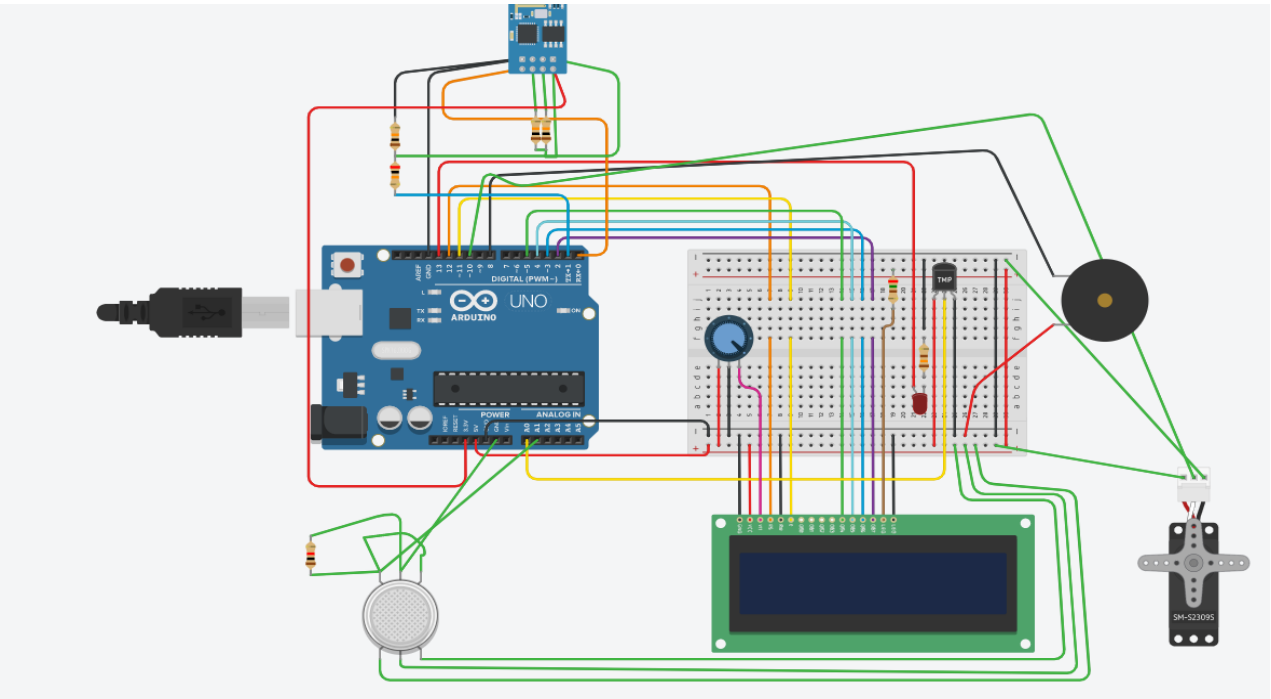

Fig 2: Circuit diagram from Tinker Cade

4.4 Code:

```
#include <LiquidCrystal.h>

#include <Servo.h>;

Servo servo_10;

float temp;

int led_red=13;

int buzzer=8;

int gas=A1;

int sensorval;

LiquidCrystal lcd(12, 11, 5, 4, 3, 2);


void setup() {

  Serial.println("AT+CWJAP=\"Simulator Wifi\",\"\"\r\n");
```

```
  lcd.begin(16, 2);
  pinMode(led_red,OUTPUT);
  pinMode(buzzer,OUTPUT);
  servo_10.attach(10);
  Serial.begin(9600);
}
void loop() {
  temp=analogRead(A0);
  temp=temp*0.4882;
  lcd.setCursor(0, 1);
  lcd.print(temp);
  lcd.setCursor(6, 1);
  lcd.print("c");
  sensorval=analogRead(A1);
  Serial.println(sensorval);
  lcd.setCursor(0,0);
  lcd.print("gas value:");
  lcd.print(sensorval);
  if (temp>=36){
        digitalWrite(led_red,HIGH);
    lcd.setCursor(8,1);
    lcd.print("Hot ");
    servo_10.write(180);
    tone(buzzer,500);
```

```
 }else{
   digitalWrite(led_red,LOW);
   lcd.setCursor(8,1);
   lcd.print("Cool");
 }
 Serial.println("AT+CIPSTART=\"TCP\",\"api.thingspeak.com\",80\r\n");
 delay(3000);
 int len = 60;
 Serial.print("AT+CIPSEND=");
 Serial.println(len);
 delay(1000);
 Serial.print ("GET /update?api_key=7U52VEK9KTT8ZLLU&field1=0");
 Serial.print (sensorval);
 Serial.println (" HTTP/1.1\z\n");
 //else{
   //lcd.setCursor(4,0);
   //lcd.print("LOW ");
   //noTone(buzzer///
 //}
 Serial.println("AT+CIPCLOSE=0\r\n");
}
```

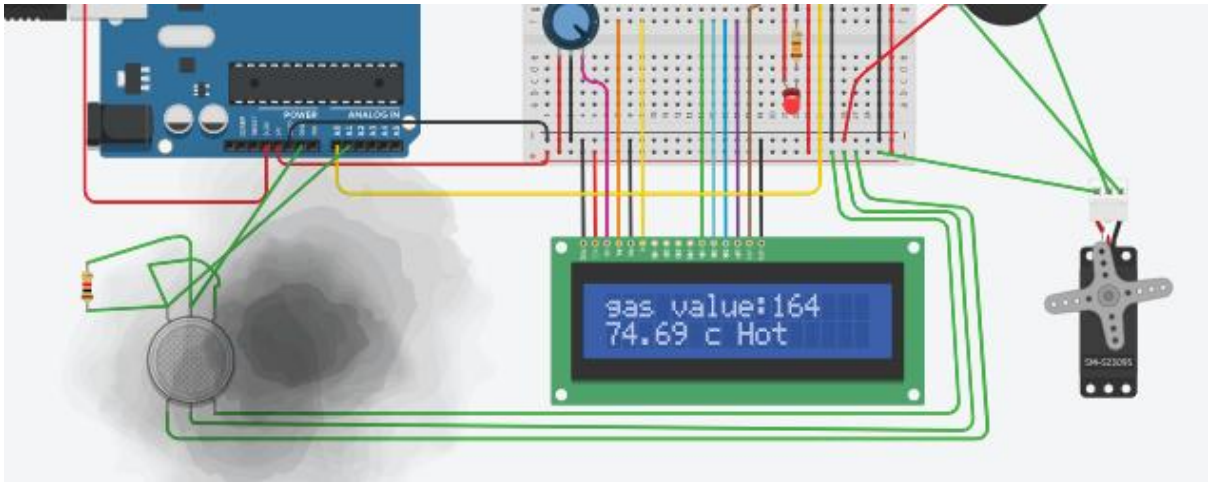

Figure 3:Sample output using the simulation of circuit and Arduino code

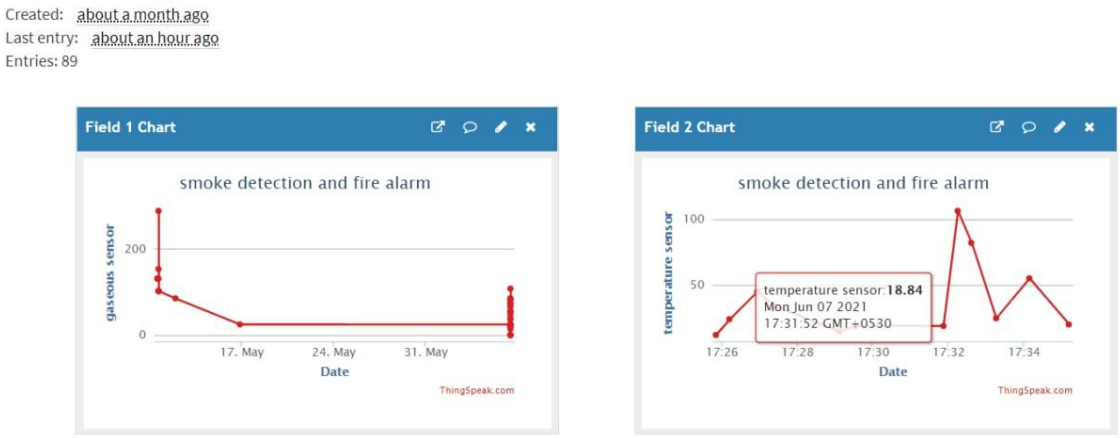

Fig 4: Thing speak channel output for Smock/gas and Temperature data

5 DATA analysis

Our parameters are temperature and gas as input independent variables and Fire severity is the dependant output variable. Fire severity is obtained by adding the corresponding temperature and gas data values. the more the gas and temperature in an area can tell us there is more intense fire in that area. Fire severity = Temperature + gas data values.

Data description

```
In [1]: import pandas as pd
        import numpy as np
        df=pd.DataFrame()
        df=pd.read_csv('alarm_data.csv',encoding='utf-8')
        df.head()
```

Out[1]:

	created_at	id	gas	temperature	fire severity
0	2021-04-27 14:50:38 UTC	1	85.0	14.00	99.00
1	2021-04-27 14:51:11 UTC	2	96.0	20.40	116.40
2	2021-04-27 14:51:26 UTC	3	165.0	54.40	219.40
3	2021-04-27 14:59:33 UTC	4	165.0	71.09	236.09
4	2021-04-27 14:59:50 UTC	5	165.0	NaN	165.00

Data Pre-processing checking null entries and outliers

```
df.isna().sum()
```

```
created_at        0
id                0
gas               0
temperature       8
fire severity     0
dtype: int64
```

As we see our main variables gas has no null value, Temperature has 8 null values and for independent variable fire severity has no null value. To correct is we substitute these null values by its median value. Mode is showing us that, when the data having more occurrences of a particular value or more frequent value in our dataset.

```
df[(df['temperature'] < lower) | (df['temperature'] > upper)]
```

	created_at	id	gas	temperature	fire severity	z_score
11	2021-04-27 15:08:40 UTC	12	266.0	107.71	373.71	-0.345791
17	2021-04-28 14:17:10 UTC	18	85.0	108.00	193.00	-0.339410

Gas outlier

```
df[(df['gas'] < lower) | (df['gas'] > upper)]
```

]:

	created_at	id	gas	temperature	fire severity	z_score
7	2021-04-27 15:07:27 UTC	8	184.00	75.97	259.97	-1.044185
11	2021-04-27 15:08:40 UTC	12	266.00	107.71	373.71	-0.345791
24	2021-05-10 09:05:09 UTC	25	177.00	81.83	258.83	-0.915244
35	2021-05-10 11:00:25 UTC	36	288.00	24.70	288.00	-2.172310
41	2021-05-16 15:05:52 UTC	42	24.71	24.70	24.71	-2.172310

```
plotPerColumnDistribution(df, 10, 5)
```

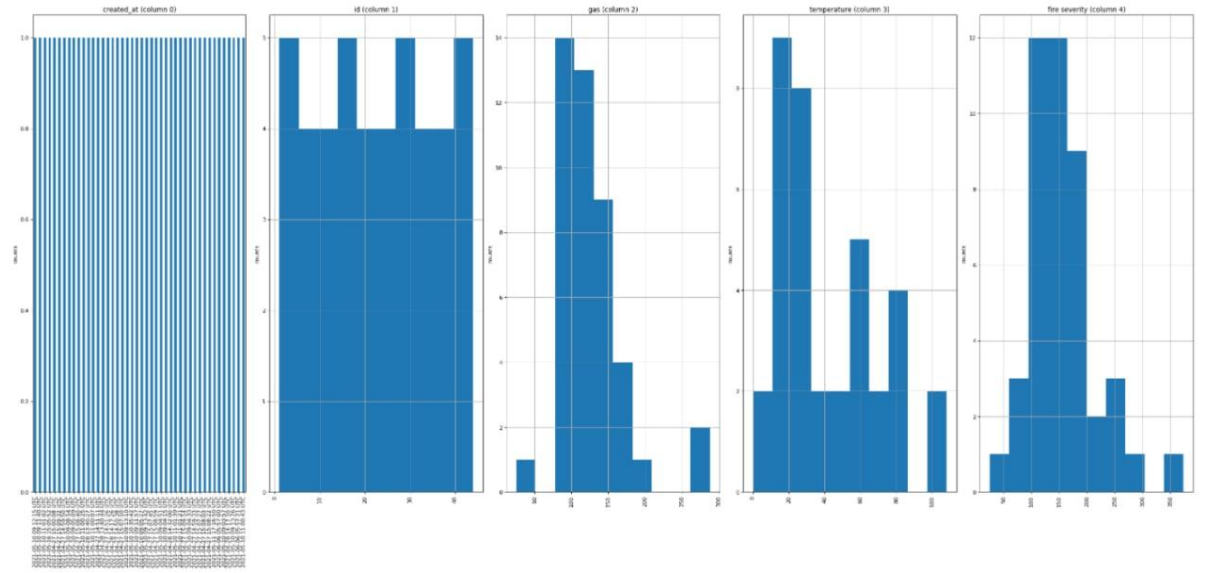

Fig 5: Histogram plot of pre-processed data

Here gas and Temperature data histogram are more similar eventually gives better normalised fire severity out put plot; Which implies that trend of gas and temperature data were similar.

5.1 Corelation using heatmap

```
import seaborn as sns
corelation = df.corr()
sns.heatmap(corelation, xticklabels=corelation.columns, yticklabels=corelation.columns, annot=True)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x143b8db01c8>
```

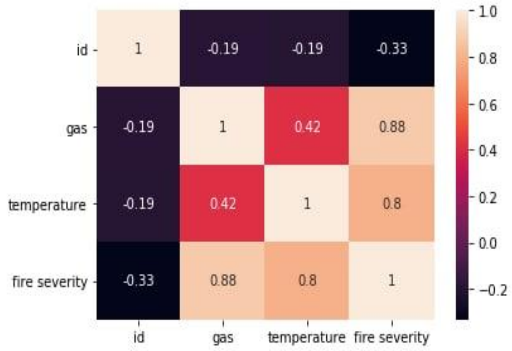

Fig 6: heatmap correlation plot

Binarization

```
Original gas data values :
 [ 85.    96.   165.   165.   165.   119.   123.   184.   156.   121.
 116.   266.    85.    85.   107.   107.   107.    85.    96.    96.
 107.   107.   107.   111.   177.   156.   111.   111.   131.   131.
 131.   131.   131.   131.   153.   288.   102.   102.   102.   102.
  85.    24.71  85.    85.  ]

Original temp data values :
 [ 14.    20.4   54.4   71.09  24.7   14.    14.74  75.97  52.7   18.84
  78.84 107.71  36.91  36.91  18.84  18.84  54.   108.    54.    54.
  71.09  81.83   0.     0.    81.83  24.7   24.7   24.7   24.7   24.7
  54.98  46.67  24.7   24.7   24.7   24.7   20.    20.    24.7   24.7
  24.7   24.7   24.7   24.7 ]

Binarized gas :
 [[0. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 1. 1. 1. 0. 0. 0. 1. 1. 1. 1.
  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0.]]

Binarized temperature:
 [[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 1. 0. 0. 0. 0. 0. 1. 0. 0. 0. 1. 0. 0.
  1. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]
```

We used threshold for temperature as 80 and 120 for gas data.

Scatter plots

```
plt.scatter(x_train,y_train,color='red')
plt.plot(x_train,y_train_predict,color='blue')
plt.xlabel('gas sensor')
plt.ylabel('fire severity')
plt.show()
```

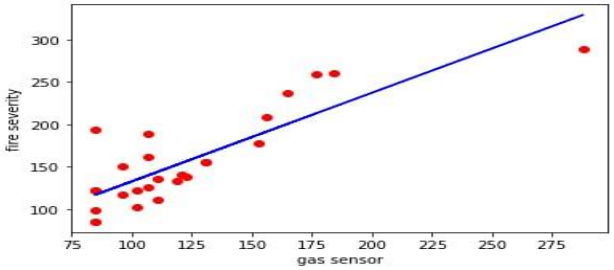

Fig 7: Scatter for fire severity versus gas data

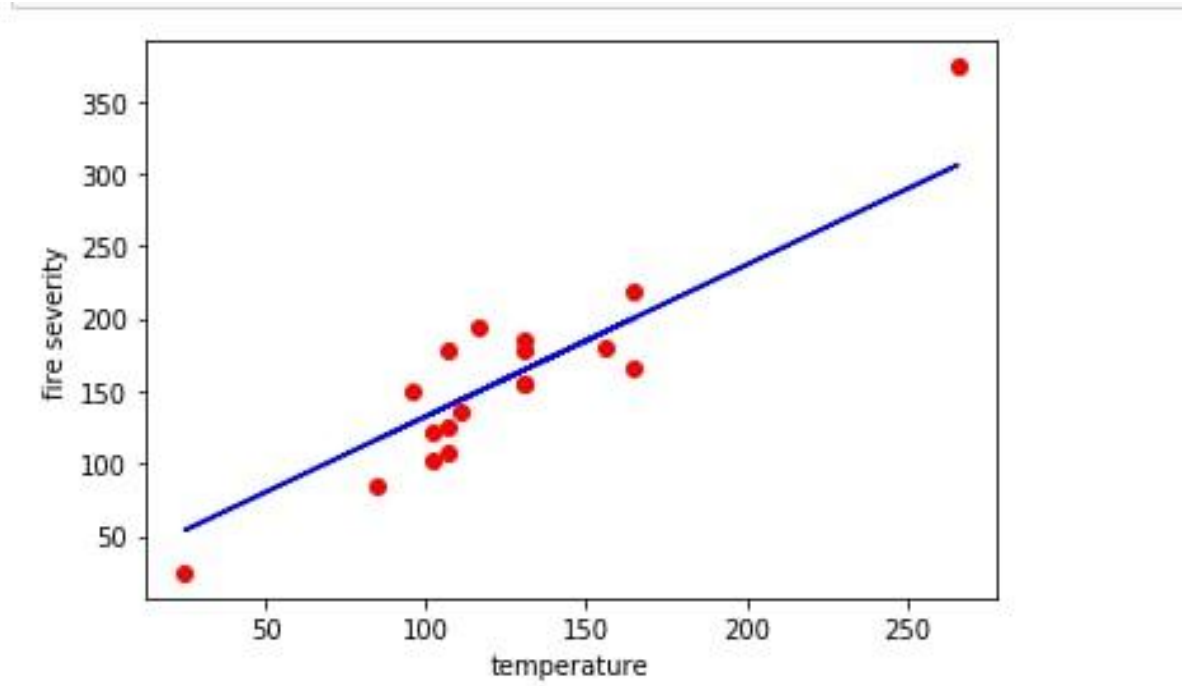

Fig 8: Scatter plot for fire severity versus Temperature data.

5.2 Model design:

To design the regression model , first we train the gas and temperature data , the using sk learn library, the model is designed.

```
from sklearn.metrics import r2_score
r2_score(y_test,y_predict)
```

```
0.8183009233410934
```

Accuracy of model based on gas data= 81.8%

```
from sklearn.metrics import r2_score
r2_score(y_test,y_predict)
```

```
']: 0.5308116273011694
```

Accuracy of model based on Temperature data = 53%

Challenge:

In this sample data is not real time / dummy data from software simulation is used. This model may not be that much accurate for real time application. Gas data can be influenced by kitchen smoke, cigarette smoke and some dusts from the environment even at normal condition

Conclusion

We took a sample dataset form thing speak. And data analysis is done. The model is relatively accurate for predicting gas datasets and poor for temperature dataset. Accuracy of model based on gas data= 81.8%. Accuracy of model based on Temperature data = 53%. Based on this model better to relay on gas sensor data than temperature sensor data.

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