IOT based Smart Helmet for Industrial Workers

PROJECT REPORT

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CS6014 - IOT AND SMART APPLIANCES

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Abstract :

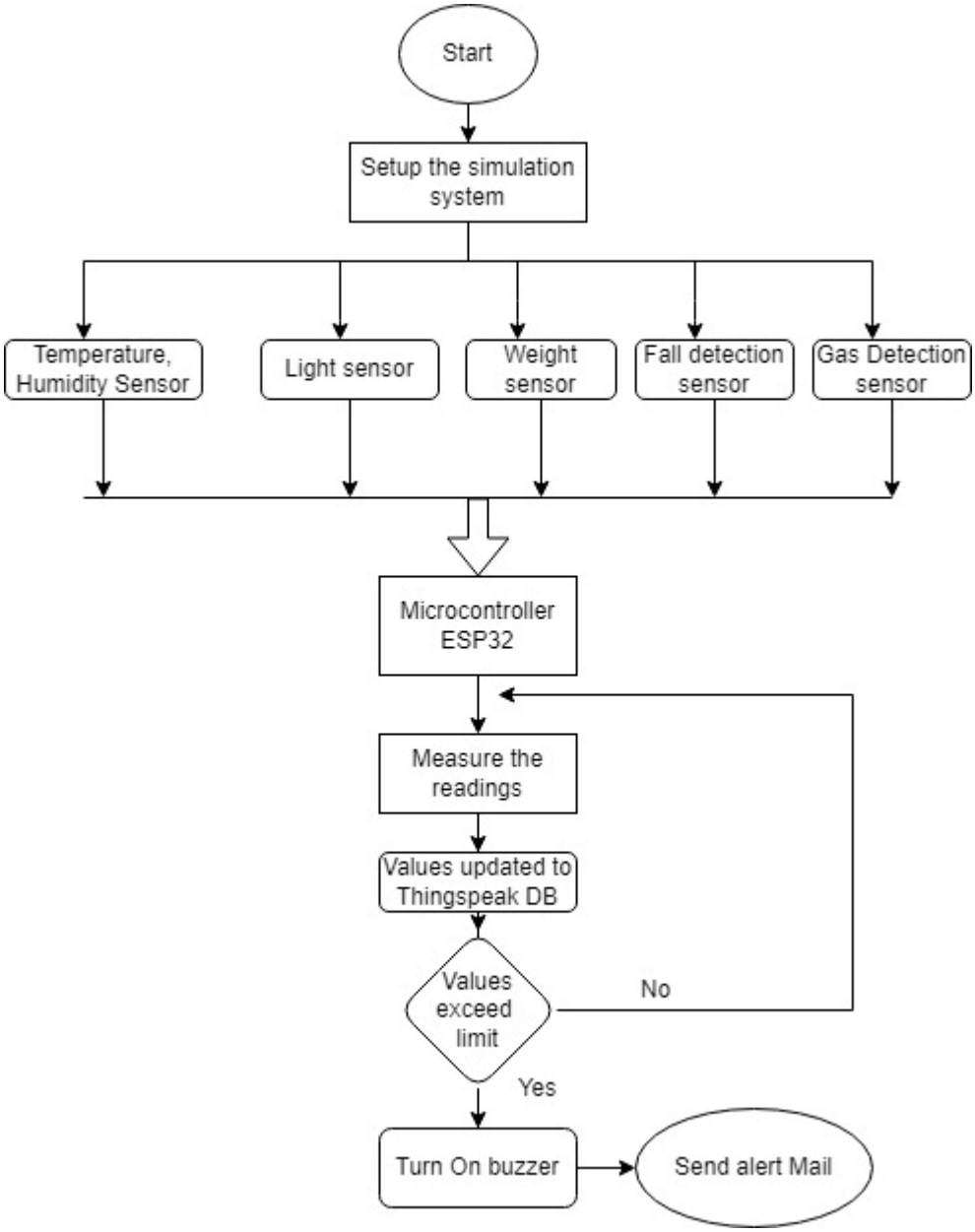
The death rate of the construction workers at the construction site is increasing day by day. But still there are no such chances to reduce this fatality rate. So for providing continuous observing of the labors and to prevent them from any health hazards during working, this system proposes a smart flexible helmet for the construction workers to provide security and rescue measures in case of any panic situations. Working environment hazards include high temperature due to fire accident, fall due to suffocation, poisoning gas leakage and gas explosion. The proposed system describes a smart low-cost helmet for the construction workers. Specially, safety becomes a main issue when you consider construction and manufacturing business. The project aims to provide a secure and safer working environment for labors thus to reducing the number of deaths happening in construction sites. The helmet includes different sensors such as temperature Sensor, gas Sensor, light Sensor etc. & IoT devices such as ESP32 which is a microchip controller, it has inbuilt WiFi module to send signals over the Wi-Fi. The aim of this project report is to describe a prototype system and integrating some different IoT technologies and some safety levels for the industry construction site.

Introduction :

The Internet of things describes physical objects that are embedded with sensors, processing ability, software, and other technologies that connect and interchange data with other devices and systems over the Internet or other communications networks. The Sensors are used to sense the activity, orientation, movement of the workers on the construction site. The rate of the construction workers at the site has been increasing every year. If the worker working 5th or 10th floor of the large building gets severe heart attack, it takes some amount of time to reach that floor and recover him. Within that time, he may be expected to death. In India, Approximately 38 construction workers die on construction sites every year. For example in 2017, there were 67 deaths, 2016 saw 55 deaths, 2015 saw 62 deaths and 2014 saw 69 deaths, etc. In order to provide continuous observing of the labour and to prevent them from any health hazards during working, this system proposes a smart flexible helmet for the construction workers to provide safety and rescue measures in case of any panic situation.

The construction and Mine industries are some of the most important industries fir the economy of India. But these industries are always preoccupied by the fact that the people that work there is always in the danger of accidents like fire bursts or gas leakages. Among all the other industries the building industry stands as the leading provider of fatalities. Day by day the death rate of the construction labours at the construction site is growing. But still there are no such medications to reduce this fatality rate. This project is based on using IoT technology to work as a remedy by detecting these accidents. Thus this reduces the response time of the people working there as can take the necessary steps once they identify that an accident has taken place. The number of fatal deaths happening in the construction sites is growing up every year. The safety and health of people is not guaranteed in construction sites. Besides affecting them physically, they are affected emotionally as well.

Architecture Diagram :



Project Modules :

Smart Helmet divided into four modules.

1) Components
2) Coding
3) Implementation and working
4) Data Analysis and Alert Mail

1)Components:

MQ2-Gas Sensor:

MQ2 gas sensor is an electronic sensor used for sensing the concentration of gases in the air such as LPG, hydrogen, smoke. MQ2 gas sensor is also known as chemiresistor. It contains a sensing material whose resistance varying when it comes in contact with the gas. This change in the value of resistance is used for the detection of gas.

Light sensor(Photo-resistor):

The photo resistor sensor module includes a LDR (light-dependant resistor) in series with a 10K resistor. The pin of microcontroller is connected between the LDR and the 10K resistor.The voltage on the pin depends on the illumination - that is the amount of light that falls on the sensor. You can read this voltage by connecting the pin of the photo resistor sensor to an analog input pin and then using the analogRead() function. when this is placed inside the helmet if it detects light then we get information that the helmet is not weared by worker.

DHT22 –Digital humidity, temperature sensor:

A temperature and humidity sensor is a device that is designed to measure the degree of hotness or coolness in the surrounding and humidity observed by the person. The working of a temperature meter and humidity depends upon the voltage across the diode. The temperature modification is directly proportional to the diode’s

resistance. Temperature sensors are broadly available as both digital and analog sensors

HX711-Load cell to weight converter:

Load Cell Amplifier is a small breakout board for the HX711 IC that allows you to easily read load cells to measure weight. By connecting the amplifier to your microcontroller you will be able to read the changes in the resistance of the load cell, and with some calibration you'll be able to get very accurate weight measurements. This can be handy for creating your own industrial scale, process control or simple presence detection.

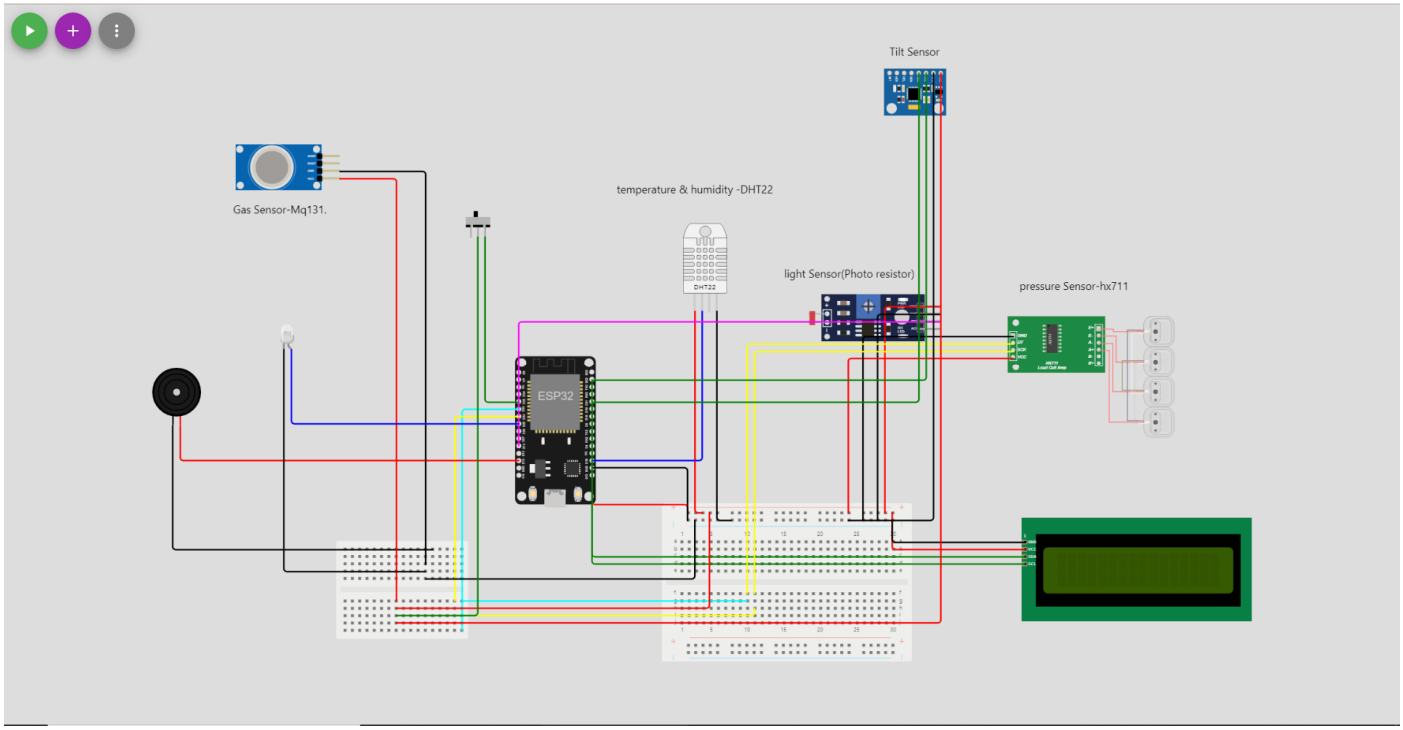
Tilt sensor:

MPU6050 is a Micro Electro-mechanical system (MEMS), it consists of three-axis accelerometer and three-axis gyroscope. It helps us to measure velocity, orientation, acceleration, displacement and other motion like features.MPU6050 consists of Digital Motion Processor (DMP), which has property to solve complex calculations.MPU6050 consists of a 16-bit analog to digital converter hardware. Due to this feature, it captures three-dimension motion at the same time. This module has some famous features which are easily accessible, due to its easy availability it can be used with a famous micro controller.

Micro controller:

ESP32 is the name of the chip that was developed by Espressif Systems. This provides Wi-Fi (and in some models) dual-mode Bluetooth connectivity to embedded devices. While ESP32 is technically just the chip, modules and development boards that contain this chip are often also referred to as "ESP32" by the manufacturer. ESP32, like Arduino, is a development board. That means it has all the features you need to create your projects.

In addition to that we have used breadboard, connecting wires, sliding switches, Led display, buzzers, Led lights.



2) Coding

Program Part:

```
#include <WiFi.h>
#include "DHTesp.h"
#include "ThingSpeak.h"
#include <Adafruit_Sensor.h>
#include <LiquidCrystal_I2C.h>
#include <Adafruit_MPU6050.h>
#include <Wire.h>
#include "HX711.h"

Adafruit_MPU6050 mpu;
LiquidCrystal_I2C LCD = LiquidCrystal_I2C(0x27, 16, 2);
HX711 scale;

const int DHT_PIN = 15;
const int ldr_pin=14;
const int buzz =13;
const int gas=35;
const int torch=25;
const char* ssid = "Wokwi-GUEST";
const char* pass = "";

WiFiClient client;

unsigned long myChannelNumber = 2;
const char* myWriteAPIKey = "66B5PY1GZ28CY23J";
const char* server = "api.thingspeak.com";

unsigned long lastTime = 0;
unsigned long timerDelay = 30000;

int temperatureC;
int humidity;
DHTesp dhtSensor;

void setup() {
  Serial.begin(115200);
  LCD.init();
```

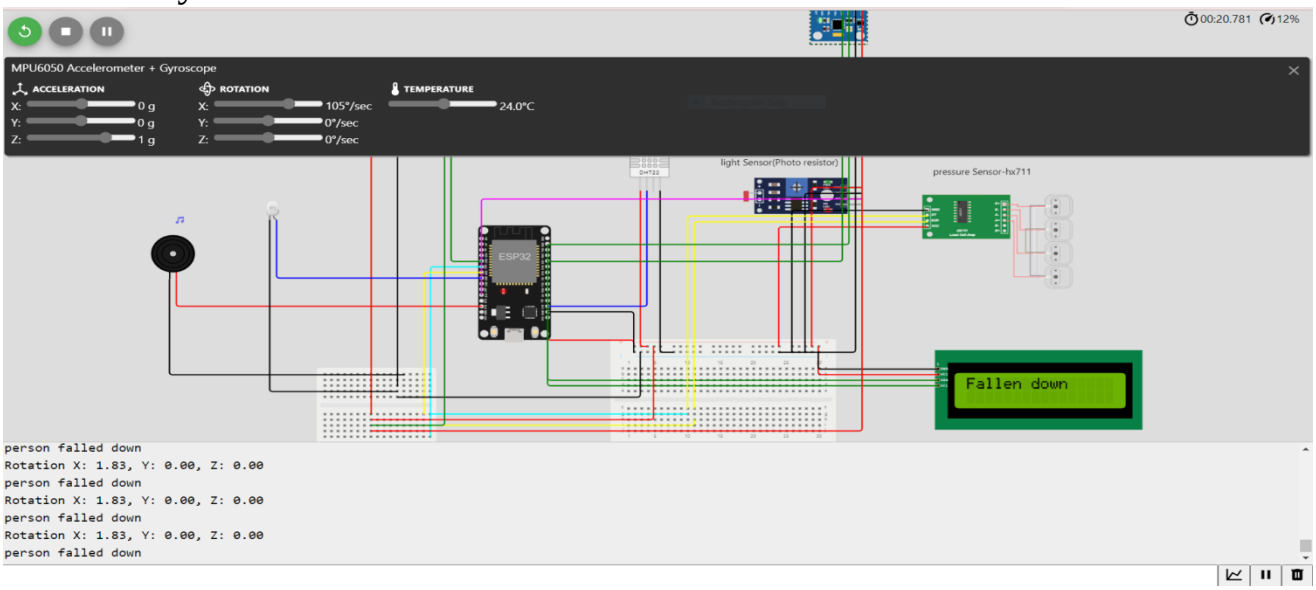
```
  LCD.backlight();
  LCD.setCursor(0, 0);
  LCD.print("IOT PROJECT");
  LCD.setCursor(0, 1);
  LCD.print("WiFi ");

  dhtSensor.setup(DHT_PIN, DHTesp::DHT22);
  dhtSensor.getPin();
  delay(10);
  WiFi.begin(ssid, pass);
  while(WiFi.status() != WL_CONNECTED) {
    delay(100);
    Serial.println(".");
  }
  Serial.println("WiFi Connected!");
  Serial.println(WiFi.localIP());

  WiFi.mode(WIFI_STA);
  ThingSpeak.begin(client);

  if (!mpu.begin()) {
    Serial.println("Failed to find MPU6050 chip");
    while (1) {
      delay(10);
    }
  }
  Serial.println("MPU6050 Found!");

  mpu.setAccelerometerRange(MPU6050_RANGE_8_G); // set accelerometer range to +-8G
  mpu.setGyroRange(MPU6050_RANGE_500_DEG);// set gyro range to +- 500 deg/s
  mpu.setFilterBandwidth(MPU6050_BAND_21_HZ);// set filter bandwidth to 21 Hz

  scale.begin(32,33);
  pinMode(ldr_pin, INPUT);
  pinMode(buzz, OUTPUT);
  pinMode(gas, INPUT_PULLUP);
  //pinMode(tilt,INPUT);
  pinMode(torch, OUTPUT);
   analogWrite(torch,0);
}

void loop() {
  sensors_event_t a, g, temp;
  mpu.getEvent(&a, &g, &temp);
  LCD.clear();
  LCD.setCursor(0, 0);
  /*The digital output ("DO") pin goes high when it's dark, and low when there's light.On the physical sensor, you tweak the small
  on-board potentiometer to set the threshold. In the simulator, use the "threshold" attribute to set the threshold voltage.
   The default threshold is 2.5 volts, or about 100 lux.*/
   analogWrite(torch, 0);

   if (digitalRead(gas) == HIGH) {
   LCD.println("Gas detected");
   Serial.println("gas detected");
   tone(buzz,1000);
   }else{
     noTone(buzz);
     if (digitalRead(ldr_pin) == HIGH) {
       LCD.println("Torch on");
       analogWrite(torch, 255);
     } else {
       analogWrite(torch, 0);
     }
     Serial.print("Rotation X: ");
     Serial.print(g.gyro.x);
     Serial.print(", Y: ");
     Serial.print(g.gyro.y);
     Serial.print(", Z: ");
     Serial.println(g.gyro.z);
   if(g.gyro.x>0 || g.gyro.y>0 || g.gyro.z>0){
     LCD.println("Fallen down");
     Serial.println("person falled down");
     tone(buzz,1000);
   }else{

```

```
  delay(200);
  float weigh=scale.get_units();

  float kg=weigh/420;
  Serial.print("Weight on head:");
  Serial.print(kg);
  Serial.println("kg");
  LCD.clear();
  LCD.setCursor(0,0);
  LCD.print("LOAD ON HEAD:");
  LCD.setCursor(0,1);
  LCD.print(kg);
  LCD.print("Kgs");
  delay(200);

  temperatureC = dhtSensor.getTemperature();
  Serial.print("Temperature (°C): ");
  Serial.println(temperatureC);
  humidity = dhtSensor.getHumidity();
  Serial.print("Humidity (%); ");
  Serial.println(humidity);
  LCD.clear();
  LCD.setCursor(0,0);
  LCD.print("TEMP:");
  LCD.print(temperatureC);
  LCD.setCursor(0,1);
  LCD.print("Humidity:");
  LCD.print(humidity);

  if(dhtSensor.getTemperature()>45 ){
          LCD.clear();
          LCD.setCursor(0,0);
          LCD.print("evacuate");
          tone(buzz,500);
          ThingSpeak.setField(1, temperatureC);
          ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);
    }

  ThingSpeak.setField(1, temperatureC);
  ThingSpeak.setField(2, humidity);
  ThingSpeak.setField(3,kg);

  int x = ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);
  if (x == 200) {
    Serial.println("Channel update successful.");
  }
    }
  }
}
```

3)Implementation and Working:

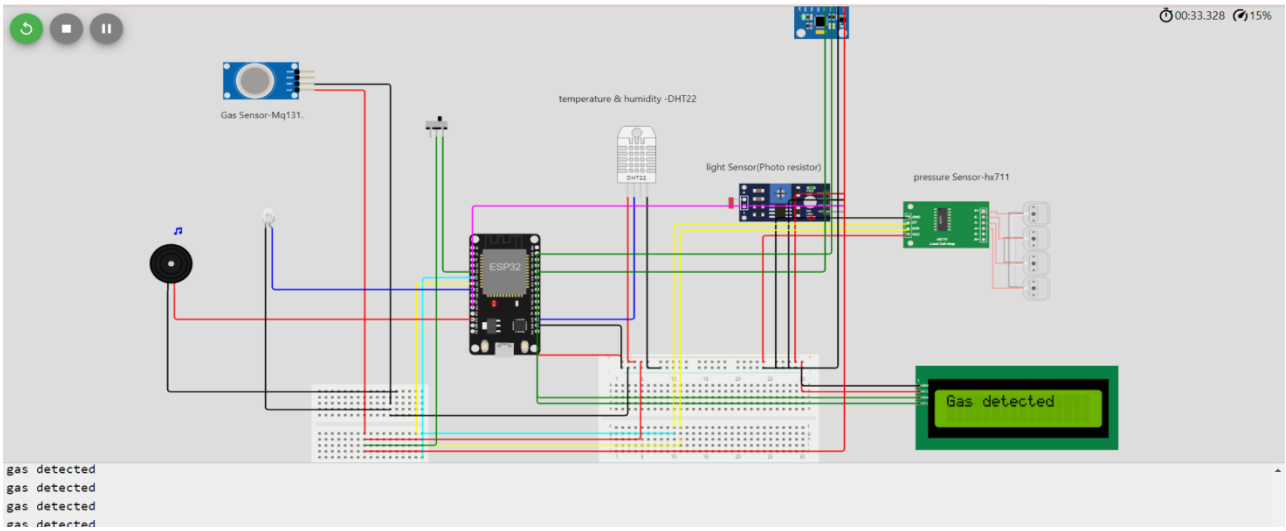
i)Fall detection:

Fall sensor – this will be used to detect if the working wearing the helmet has fall down. It could be because of various factors in mine like unconsciousness due to low oxygen etc. MPU6050 is used in this case which is a MEMS which has accelerometer, gyroscope and temperature sensor in which gyroscope value gives us details about angle of the worker wearing this by this an unusual value help us identify that the worker has fallen immediately buzzer alarms that worker has fallen so that other workers nearby finds and rescue him.



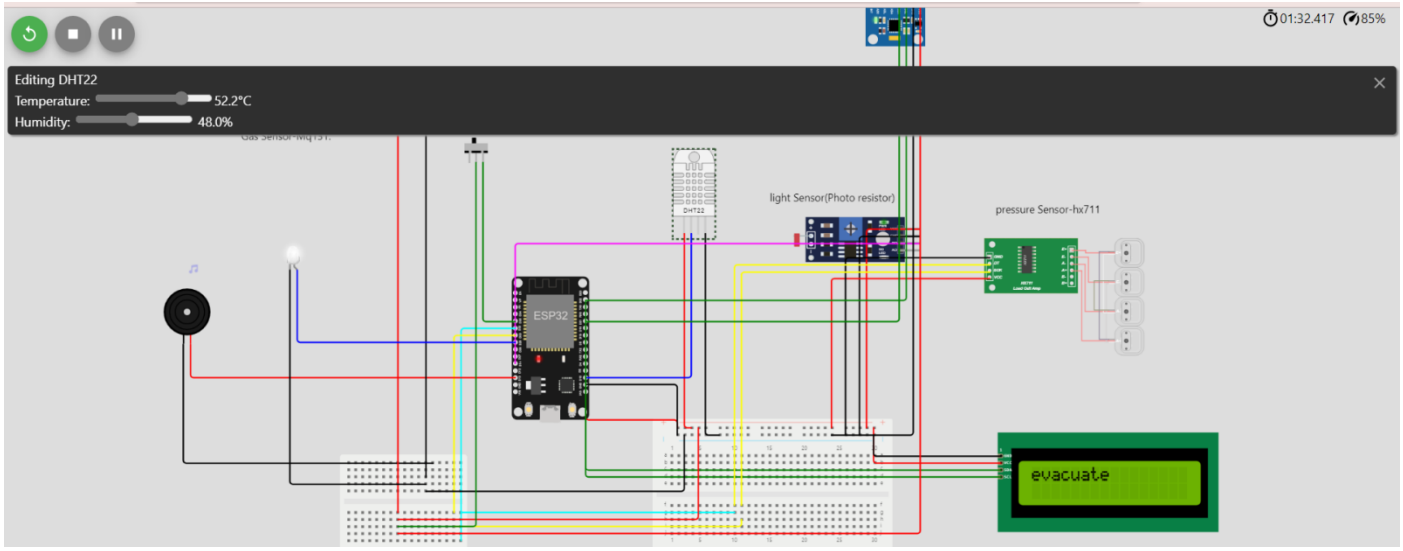
ii) Gas Leakage Detection:

Gas sensor – There are many types of gas sensors which detects different gases and its concentration. For coal mines where methane is maximum so for that is MQ4 is used here. when Harmful gases comes into contact with sensor it detects and warns the person wearing helmet with a buzzer so that the workers can evacuate from the location.



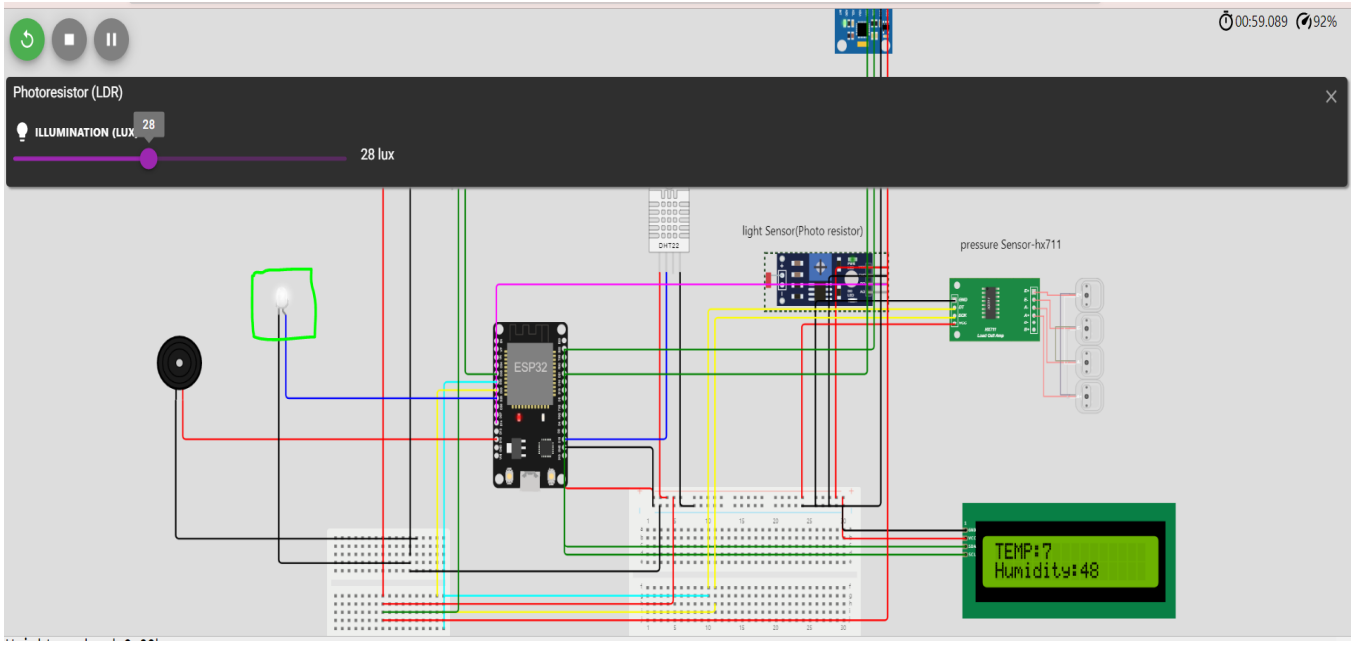
iii) Temperature warning

DHT11 Humidity and temperature sensor measures temperature in surrounding and humidity encountered by the worker. Humidity beyond threshold indicates worker to move to some other place were ventilation is good If suddenly fire situation is occur around the worker then temperature goes above the threshold value say 45 degree Celsius which is set on Micro controller ESP32 then the beep of buzzer. That is for local alert system. Again in this situation Wi-Fi Module send the notification for manager they will help the worker. In this way temperature Sensor will work.



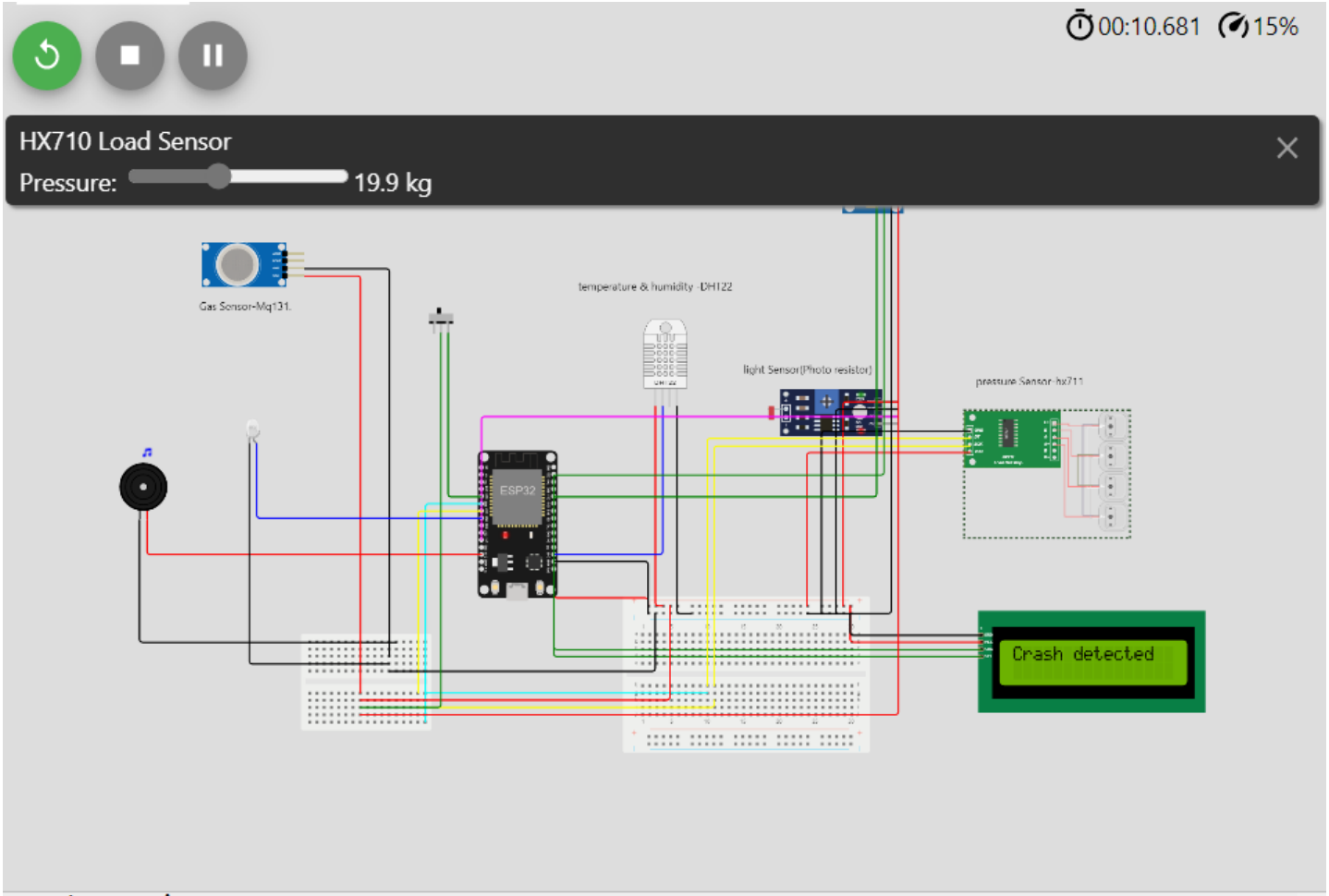
iv) Automatic torch system

photo resistor Light sensor will sense the brightness of the area around the workers where the worker are working and report it in lux unit of illuminance in international system in SI. If it is less than threshold say 100 then we decide it is dark then the torch-light will be turned on.



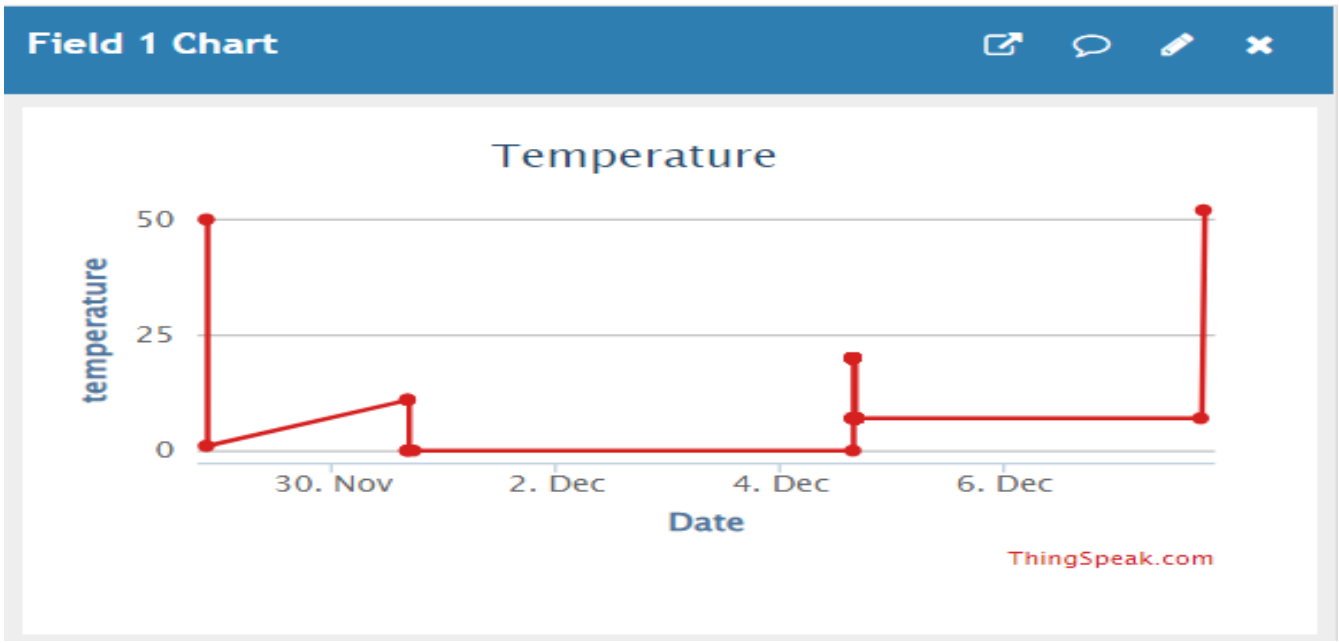
v)Crash detection

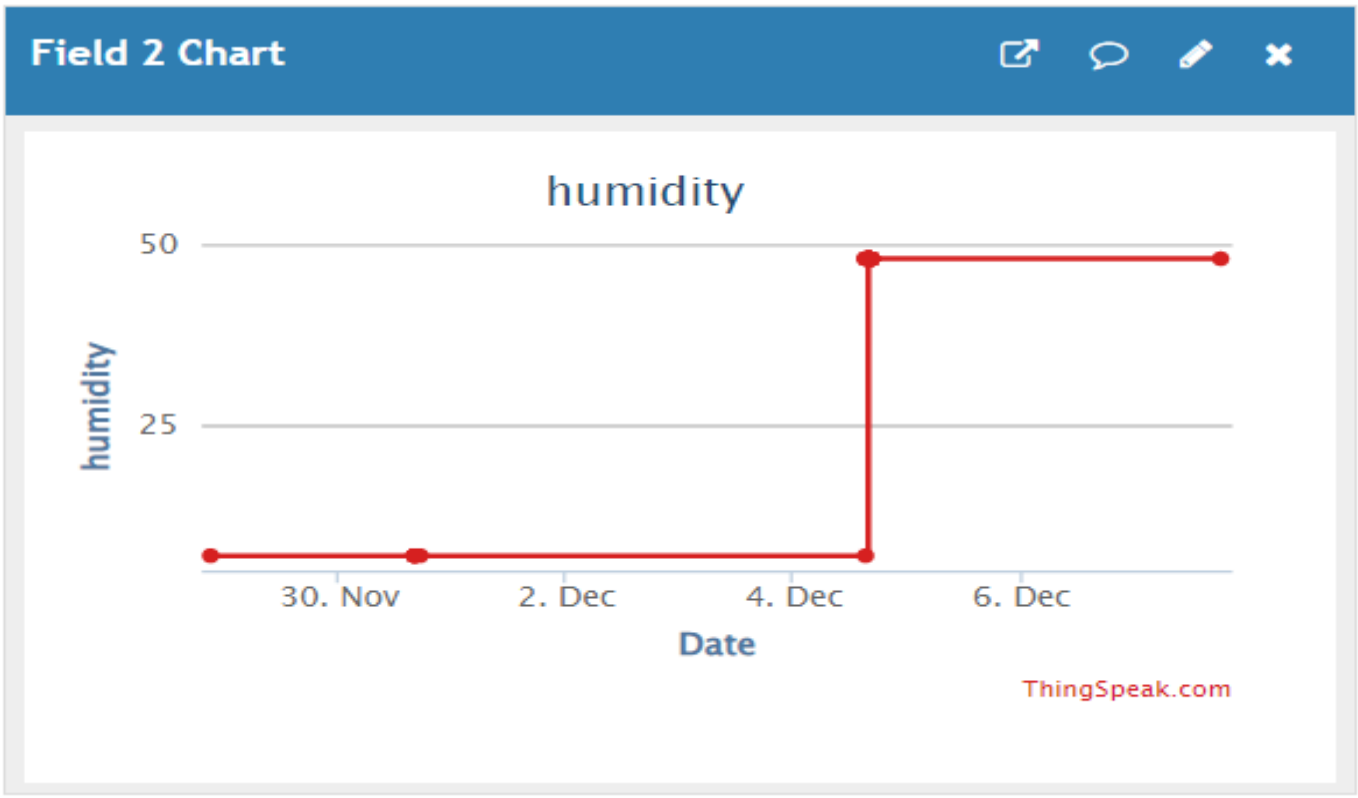
HX711-Load cell to weight converter measures the weight applied on to the sensor .Even nowadays coal miners work inside dark mines if something falls on their head or any crash. when the sensor fixed on the top of the helmet may detected pressure experienced by coal mine workers on head and gives a warning if the weight is more than 8kg and a alarm buzzer is turned so that rescue members can help.



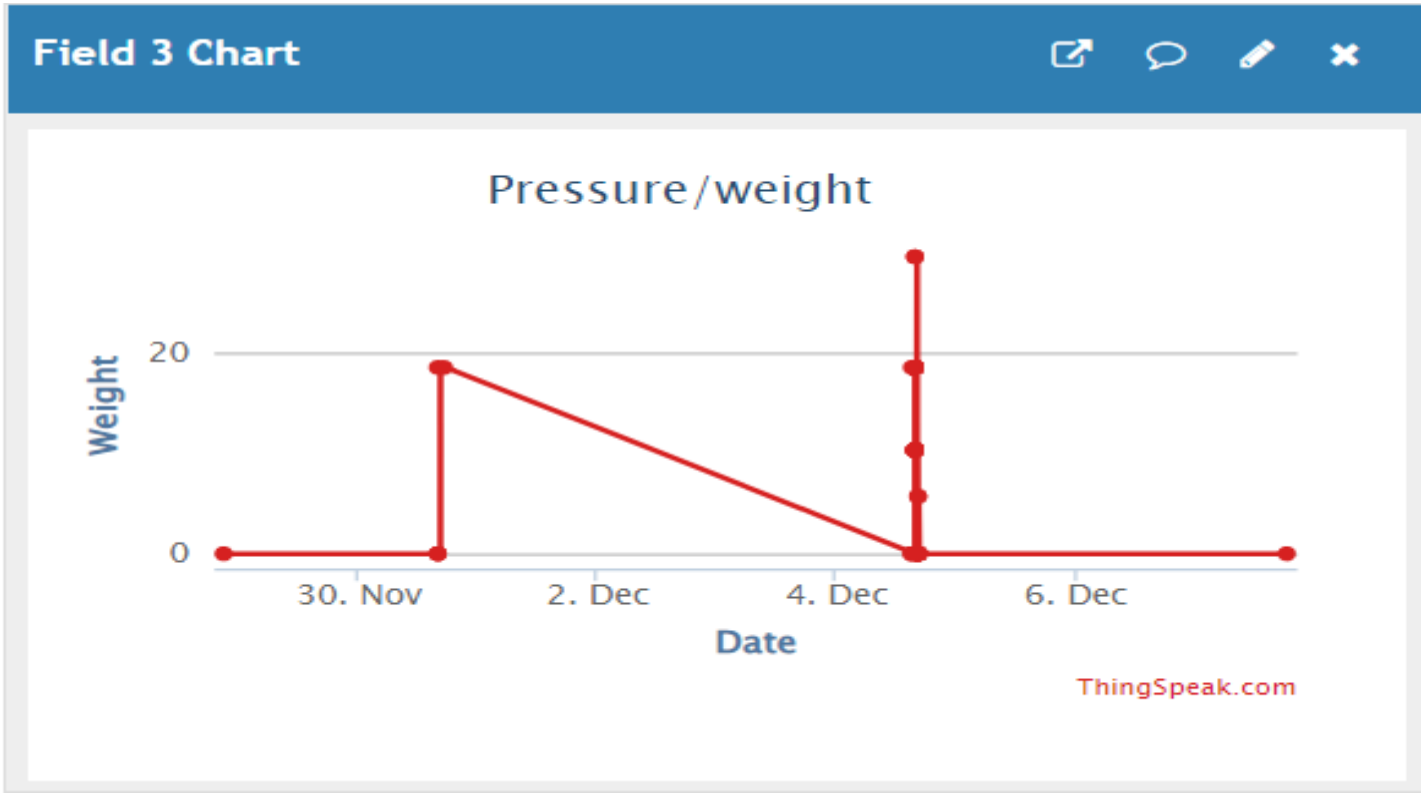
4)Data Analysis and Alert Mail:

The real time data of humidity , pressure during crash and temperature are sent to the ThingSpeak cloud and displayed in form of graphs for easy analysis and data interpretation. Field 1 is temperature , Field 2 is Humidity and field 3 is pressure applied on helmet during any accident. When the values increase threshold warnings are shown on dashboard.

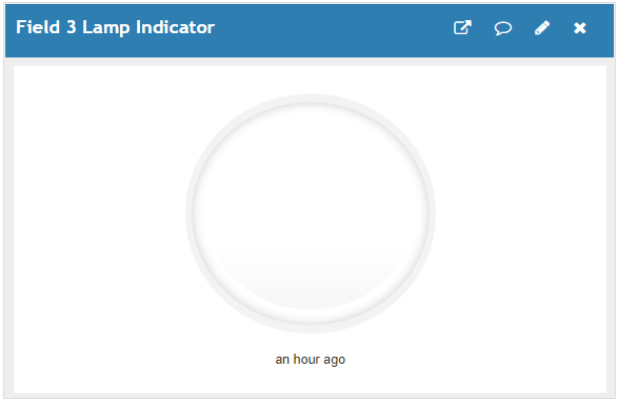


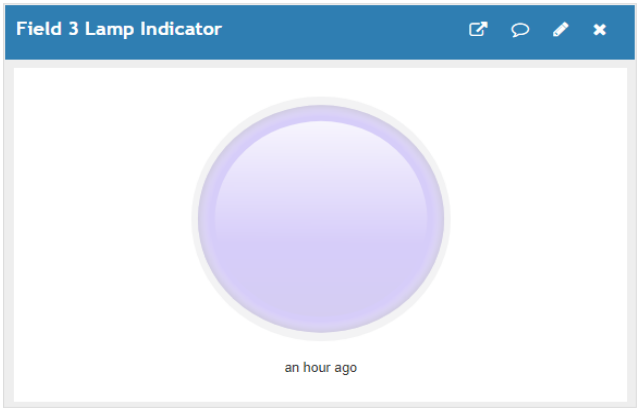


Temperature and humidity collected from smart helmet is sent via WIFI module of the microcontroller is sent to our Thing speak account via our API key which is visible in our Dashboard.

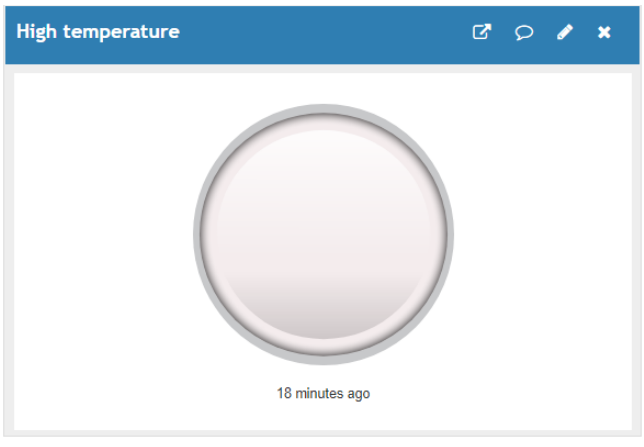


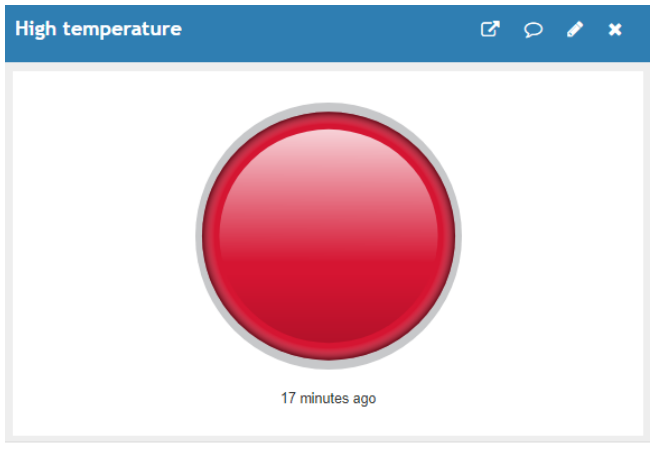
When large pressure is applied on workers helmet its warning to us as crash detection so the light in dashboard glows to warns us.





Similarly when temperature gets high beyond threshold 45* c then a red light glows as warning as an indication to take proper recovery measures to rescue worker





By using the react feature in the thing speak we can trigger an email when a condition is met , we have set the condition if temperature value goes beyond threshold 45*c then a mail is triggered to the company so that fire emergency steps can be made to help the workers out there.

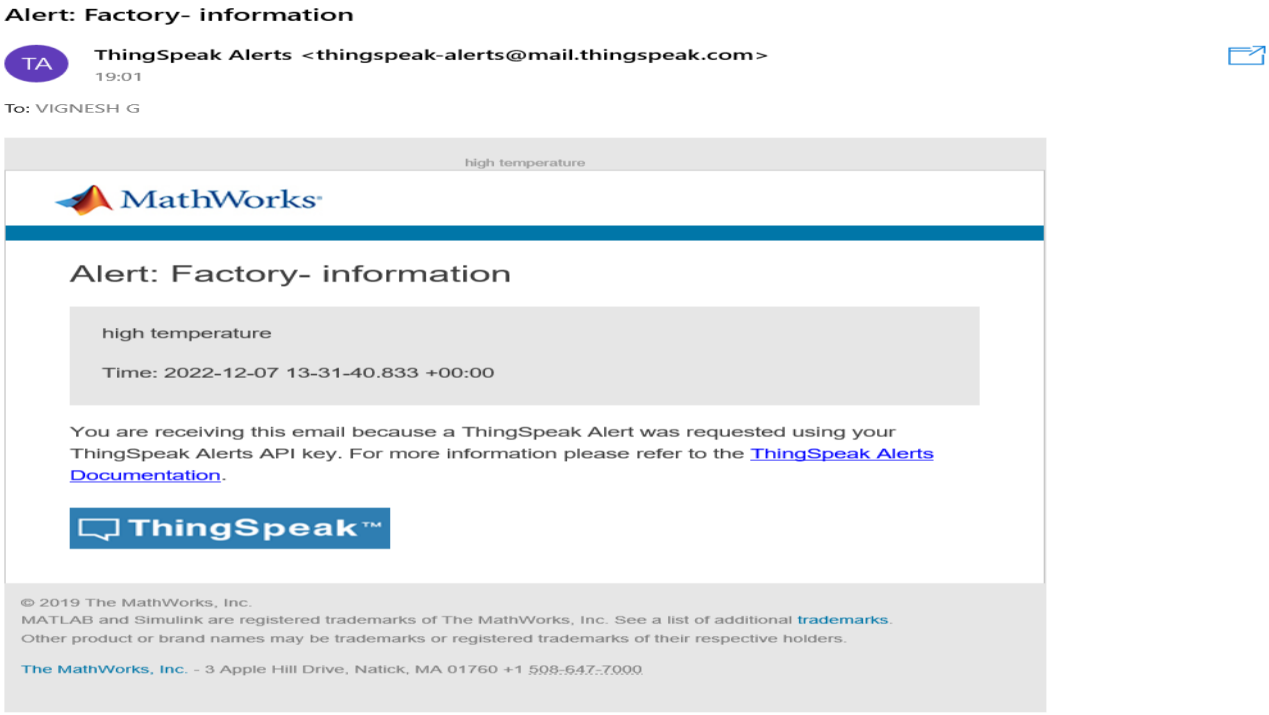
Apps / React / High temperature

Edit React

Name:	High temperature
Condition Type:	Numeric
Test Frequency:	On data insertion
Last Ran:	2022-12-07 13:31
Channel:	smart-helmet
Condition:	Field 1 (temperature) is greater than 45
MATLAB Analysis:	Read Channel to Trigger Email 2
Run:	Each time the condition is met
Created:	2022-11-28 11:40 am

```
channelID = 1956660;

% Provide the ThingSpeak alerts API key.  All alerts API keys start with TAK.
alertApiKey = 'TAKJPE9csd0t76C6Bhm';

% Set the address for the HTTP call
alertUrl="https://api.thingspeak.com/alerts/send";

% webwrite uses weboptions to add required headers.  Alerts needs a ThingSpeak-Alerts-API-Key
options = weboptions("HeaderFields", ["ThingSpeak-Alerts-API-Key", alertApiKey ]);

% Set the email subject.
alertSubject = sprintf("Factory- information");
readChannelID = 1956660;
% TODO - Enter the Read API Key between the '' below:
readAPIKey = 'FCGJ8S3VY79J59ZK';

%% Read Data %%
data = thingSpeakRead(readChannelID, 'ReadKey', readAPIKey,'Fields',1);


%% Analyze Data %%
% Add code in this section to analyze data and store the result in the
% 'analyzedData' variable.
analyzedData = data;


if (analyzedData>45)
    alertBody = 'high temperature';
else

end

try
    webwrite(alertUrl , "body", alertBody, "subject", alertSubject, options);
catch someException
    fprintf("Failed to send alert: %s\n", someException.message);
end

```

This is the sample mail sent to the organization or companies email to warn.



Result :

The Smart Helmet is a personal protection equipment for industrial employees that aids in preventing injuries while on the job. It is one of the most innovative ideas in the history of the industrial sector. We reviewed the benefits of the Smart Helmet for industrial safety during our work. The helmet features a built-in WIFI attachment that can report all signal outputs to the operator at all times, which is very useful for industrial employees. Furthermore, there is an anti-fall alarm that alerts the worker when there is a risk of falling and requires the worker to put on safety equipment. As a result, there's a MQ2 sensor for measuring humidity in the air and a DHT11 sensor for measuring temperature. With all of these protections in place and all of the efforts taken to eliminate all potential hazards at work, I believe we've successfully solved every challenge. Additional sensors and circuits made the safety helmet project more effective.

Future works:

Sometimes industrial workers like coal miners might be working in large area, so the buzzer alarm alone is not enough in those cases to identify the person to provide some medical assistance so that in smart helmet we can incorporate GPS sensor(GPTA010 module) which in case of any emergency situation can be used to located the person by the company arranged rescue team, so that GPS send the location accurately with latitude and longitude to the company via inbuilt WIFI module of microcontroller to thing speak analytics platform.

References :

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2) Mingi Jeong,, Hyesun Lee, Myungnam Bae, Dong-Beom Shin, Sun-Hwa Lim, Kang Bok Lee ,“Development and Application of the Smart Helmet for Disaster and Safety”, Published in: 2018 International Conference on Information and Communication Technology Convergence (ICTC), Added in: IEEE Xplore.

3) P.Roja , D.Srihari, “IOT Based Smart Helmet for Air Quality Used for the Mining Industry”, Published in: IJSRSET, Volume 4, Issue 8, 2018.

4) C. J. Behr, A. Kumar and G.P. Hancke, “A Smart Helmet for Air Quality and Hazardous Event Detection for the Mining Industry”, Published in: IEEE International Conference on Industrial Technology (ICIT) 2016.

5) Wokwi Discord community. (www.wokwi.com)