IOT BASED SAFETY KIT FOR CONSTRUCTION WORKERS

A PROJECT REPORT

Submitted by

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in partial fulfillment for the award

of the degree of

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE ANDENGINEERING

PANIMALAR ENGINEERING COLLEGE, CHENNAI-600123.

ANNA UNIVERSITY: CHENNAI 600 025

APRIL 2021

BONAFIDE CERTIFICATE

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ACKNOWLEDGEMENT

We express our deep gratitude to our respected Secretary and Correspondent **Dr.P.CHINNADURAI, M.A., Ph.D.** for his kind words and enthusiastic motivation, which inspired us a lot in completing this project.

We would like express our heartfelt and sincere thanks to our Directors **Tmt.C.VIJAYARAJESWARI**, **Dr.C.SAKTHIKUMAR, M.E., Ph.D.,** and **Tmt. SARANYASREE SAKTHIKUMAR B.E.,M.B.A.,** for providing us with the necessary facilities for completion of this project.

We also express our gratitude to our Principal **Dr.K.Mani, M.E., Ph.D.** for his timely concern and encouragement provided to us throughout the course.

We thank the HOD of CSE Department, **Dr. S.MURUGAVALLI , M.E.,Ph.D.,** for the support extended throughout the project.

We would like to thank my Project Guide **Mrs.RDevi,B.Tech.,M.E.,**our class in-charge **Dr.D.Anuradha,M.E.,Ph.D.,**and all the faculty members of the Department of CSE for their advice and suggestions for the successful completion of the project.

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ABSTRACT

The Indian Institute of Technology (IIT) conducted a survey and found out that about 48,000 workers die every year in the due to accidents which occur in their occupation, that is approximately equal to around 38 workers losing their lives every day, and 38 families losing the sole bread earner of their families. India has a total population of 138 crore and a total workforce of 46.5 crore, so a sum of approximately 46 crore people are in a need of a solution to this grave danger which they face every day. There are no products designed at present to help reduce the number of deaths in the construction field, so our product will be one in a kind. A handy IOT based safety kit is designed for the construction workers. Each kit has a unique ID, and is to be worn at all times by the workers, when they are on – site. If an accident occurs on the site causing the user to get stuck between a mass of debris, this kit will be instrumental in the rescue process.

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ILO	International labour organization
IOT	Internet of things
OBC	Other backward caste
UP	Uttar Pradesh
CO	Carbon monoxide
CH4	Methane
LPG	Liquefied petroleum gas
HIC	Head injury criteria
YOLO	You only look once
CAN	Controller area network
ID	Identity
SOC	Security operations center
TCP	Transmission control protocol
IP	Internet Protocol
GPS	Global positioning system
DOS	Disk operating system
MEMS	miniaturized mechanical and electromechanical elements
ADX	Average Directional Movement Index
HB	Heart beat
UML	Unified Modeling Language
UART	Universal asynchronous receiver-transmitter
APP	Application
LED	Light emitting diode

1. Introduction:

“There are 6 crore construction workers in total in the country. Only 3.5 crore are registered with welfare boards.” – Labour Union India.

India also aims at making our construction market the **third largest globally** by 2025. Surprisingly, while it aims for greatness, the sector is also one where the workforce is forced to work in **deplorable conditions** with no provision of basic shelter, food, sanitation, safety, health care. According to ILO numbers quoted in a British Safety Council study, **11,616 construction workers on an average die due to work-related hazards in a year.**

The construction industry saw a sharp rise in employment due to the increase in demand for labor and people looking for ‘better work opportunities’ during the late 80s and early 90s. The increase in employment should have actually promoted steadiness in the labor industry. Instead, given the vulnerability of the labor industry that had always existed, it tends to grow more over time. Many **agricultural laborers shift hastily towards the construction industry** in anticipation of steadier and/or additional income. The big fishes started hiring people from remote villages in the promise of a better lifestyle. However, once brought to the city, workers were left to fend for themselves and provided almost no training, education or safety mechanisms to protect themselves or their families. For example, Delhi has **5,39,421 workers registered** totally, but only **1,28,394 are active** as per the state website. It is not clear how many of these registered workers are local and how many are migrants, because none of the systems we have come across, captures this since it is an impossible task.

Figure 1.1

Adding to that it is also observed that a worker usually completes his **90 days of work by working in different sites** and thus gets enrolled in different trade unions tied to respective contractors. No trade union then has the capacity to authenticate or guarantee the worker's full 90 days of work, leading to workers **missing out on safety benefits**. To circumvent this, workers are expected to provide full details and affidavits mentioning their previous work experience – a daunting task to say the least. Most often, therefore, they **prefer to remain undocumented**.

To **counter deaths** under easily avoidable circumstances, it is also suggested that the **government distributes safety kits** instead of **succumbing to cash transfers**, which can easily be used for other things.

Hence, we worked to **build wearable device such as a smart kit** for monitoring the construction workers and to provide them a **safer and secure working environment**. The devices help in keeping track of the pulse, and body temperature of the worker. Moreover, care is also taken to provide emergency alert during any slip or fall of the worker (Both in-house and out-house fall). The rest of the document provides a detailed study about the proposed system.

Our system is built based on **Internet of Things (IoT)**which refers to a system of interrelated, internet-connected objects that are able to collect and transfer data over a wireless network without human intervention.Our planet has more connected devices than people. The IoT will transform the way businesses, governments, and humans interact with the rest of the connected world.But as with any new technology, IoT disadvantages do exist. Concerns include acceptance, cost, connectivity, security, and more. As many new players enter the field, standards still are being set. But even with these challenges, the end goals of IoT have so much promise.

1.1 Overview:

Construction workers - they build houses and are seen arduously and meticulously laying bricks on cement-sand mortar up to hundreds of metres in height stepping on dangerously built make-shift ladders of bamboo loosely tied by coconut ropes and risking their lives only to make somebody's dream home come true.

But what about their own life?

They are condemned to live in shanty hutments just below the building which they are making and once the building is complete they have to shift with their meagre belongings to another construction site and again the same vicious circle moves.

They can never dream of their own roof. How can they?

They don’t even get the minimum wages and whatever money they get is totally insufficient to meet their daily ration. They live a life of just above stray animals.

Figure 1.1.1

This is the sad tale of the construction workers. There are such **8.5 million workers engaged in building** and other construction activities in India. They constitute the most vulnerable segment amongst the unorganised workforce in the country owing to their temporary nature of work and lack of a definite employee-employer relationship. Apart from this there is never a fixed working hour for them.

Most of the construction workers are migrant labourers and landless labourers from **U.P, Bihar, Orissa, West Bengal, Madhya Pradesh, Rajasthan** and other economically weaker regions of India. A majority of them are OBC, Dalit or Scheduled tribes who come to urban centres like Delhi, Mumbai and other Metros and cities in search of livelihood.

The **risk to life and limb** is manifold more than that of their counterparts engaged in other organised/unorganised sectors. They **do not get any proper medical facility** and any statutory grievance mechanism is also totally absent for them.

With the advancement of engineering technology everyday, it is our responsibility to provide a safe environment to this large cluster - skilled, semi-skilled and unskilled workers.

In event of workers wearing our device while working, it will be useful in the longer run, and a peace of mind can be achieved in the knowledge that if anything goes wrong, quick measures can be taken during the rescue process.

Figure 1.1.2

The technology we have employed- Internet of things enablesto create a set of connections between many sensors and modules. In our proposed product, this network of things help the supervisors in the construction field in daily life and especially during rescue missions if any untoward accident occurs to the construction workers, on the site.

1.2 Problem definition:

"The construction sector contributes to 9% of the GDP and employs 44 million workers, becoming the second largest employer in India in 2017"

- According to government of India.

Construction is a multifaceted industry which includes building small houses to complicatedstructures like large apartments and shopping malls,undergroundparkings etc. This involves various risk factors to life's of workers.The Mumbai **building collapse 2013**, took place in a suburb of Thane in Maharashtra, India. It has been called the worst building collapse in the decade nearly **74 people** (18 children,33 men and 23 women) **were killed**, while **100 survived** with **fatal injuries**.The building was under construction and **did not have an occupancy certificate** for its 100 to 150 low- to middle-income residents. Living in the building were the site **construction workers and families**.

This was considered as one of the **worst disasters** in the construction industry. Workers may not be aware of the external conditions such as rise or fall of temperature, pressure etc. Sometimes workers even**collide with the heavy objects** like bricks and hard iron rods which risks their life. In event of any disaster workers are not able to **communicate with the outside world**. In this case, the **smart kit**system becomes an **essential and helpful measure to protect them** from various accidents. This project aims at designing a smart kit for hazardous event detection, monitoring the surrounding environmental conditions and updating information like **GPS location** and multiple **sensor data** to the central console for easy tracking. This secures the life of workers in construction industries.

2. Literature survey:

1.Pulishetty Prasad et all proposed a system “Zigbee Based Intelligent Helmet For Coal Miners” in 2017. It discovers real time monitoring with timely warning intelligence when there is a leakage of gas, rise or drop in temperature and informs control station by using new age Zigbee wireless technology. This system helps in pointing the location of a person accurately and covers a massive area. The major disadvantage of this system is that it is particularly focused on workplace safety rather on workers.

2.Mangala Nandhini. V et all proposed a system "IOT based Smart Helmet for Ensuring Safety in Industries" in 2018.This system provides actual timedetection of threatening gases like CO,CH4, LPG , temperature and humidity and provides emergency alert to the control station. Wi-Fi is used to transfer data from the helmet to the monitoring station. The reliability and durability of the communication system is poor.

3.Raghavendra Rao B et all proposed a system "‘SIRASTRANA’: A Smart Helmet for Air Quality and Hazardous Event Detection for the Mining Industry "in 2018.In the event of miners struck by a hard rock or any object on their heads with a force over a stated limit of 1000 on the HIC (Head Injury Criteria) the accelerometer alerts the monitoring station.Helmet Removal Sensor it alerts when the worker has removed the helmet during working hours. But this system does not provide any other protective measures in case of emergency conditions.

4. K.Divya et all proposed a system "A Smart Helmet For Improving Safety In Mining Industry" in 2017.In case of any poisonous gas detection the helmet

provides oxygen by opening a valve. It detects hazardous event, monitors and provides oxygen supplements to avoid the inhalation of poisonous gases. The helmet is too heavy since it contains oxygen cylinders which is uncomfortable to work with.

5.C.Jagadeeswari et all proposed a system "Hard Hat Detection Using Deep Learning Techniques" in 2020.This system uses YOLO algorithm – a much faster algorithm in object identification to detect whether the worker is wearing the helmet during working or not. The main advantage of this system is that it protects the head which is the most crucial part of the body.But this system has a clear motive to protect only the head and does not provide any other support during emergency situation.

6. Jie Luo et all proposed a system "Highly Portable, Sensor-Based System for Human Fall Monitoring" in 2017.This system consists of a highly portable sensor unit including a triaxis accelerometer, a triaxis magnetometer, and a mobile phone and with the data from these sensors, systemobtains the acceleration and Euler angle (yaw, pitch, and roll), which represents the orientation of the user’s body. This system helps in fall detection and help in daily life of elders. It focuses onproviding safety for elderly people but not for the industrial workers.

3. System analysis:

3.1. Existing system:

1. Yongping Wu and Guo Feng implemented helmets that uses the Bluetooth wireless transmission system for the monitoring the working environment. As a standard of unified global short-range wireless communication, Bluetooth technology is to establish a common low power, low-cost wireless air interface and controlling software opening system . At the same time, the system uses CAN bus technology maturely, has realized the combination of wired and wireless data transmission system. The main difficulty of this system is that the Bluetooth is short distance wireless technology and use of cabling is difficult. When a natural calamity occurs, the cabling will gets damaged. So the reliability and long life of conventional communication system is poor.
2. R. Jingjiang Song, Yingli Zhu proposed automatic monitoring system for industrial safety based on wireless sensor network. The sensor groups of the system intensively monitor temperature, humidity in the working area.The parameters measured are sent to wireless communication module by the micro- controller. The collected information is sent to long-distance monitoring center by cable. So the reliability and long life of conventional communication system is poor. The another problem is that the working condition of industries is very noisy and if the distance of the workers and system is long,workers will not get proper message
3. Pranjal Hazarika presents implementation of safety helmet for workers. This helmet is equipped with methane and carbon monoxide gas sensor. This sensor sense the gas and the data is transmitted to the control room wirelessly, through a wireless module called Zigbee connected with the

helmet. This system does not working conditions of the workers and whether theworkers wear the helmet or not.The main difficulty of the system is the usage of zigbee technology.Zigbee technology has small area coverage and hence transferring to the monitoring agent is difficult to transfer data from the working area long distance monitoring unit.

At present, the only protection the construction workers in India especially get are the hats and gloves to wear.There are no products designed at present to help reduce the number of deaths in the construction field, so our product will be one for a kind.

Figure 3.1.1

3.2. Proposed system:

Our system provides real time monitoring of industries from the monitoring station. It is precisely a small kit which comprises of the following components SPO2 sensor, ESP8266 board, location tracker (bluetooth), speaker, ADX–average directional index (sensor-MPU6050), LM35 (temperature) and Google firebase is used as the cloud platform.A handy IOT based safety kit is designed for the construction workers.Each kit has a unique ID, and is to be worn at all times by the workers, when they are on – site.If an accident occurs on the site causing the user to get stuck between a mass of debris, this kit shows the pulse rate, location and identity of the worker, to the chief manager. By using this application, rescue process can be undertaken at a faster pace, thus ensuring that many valuable lives are saved from the clutches of suffocation and eventual death.

Figure 3.2.1

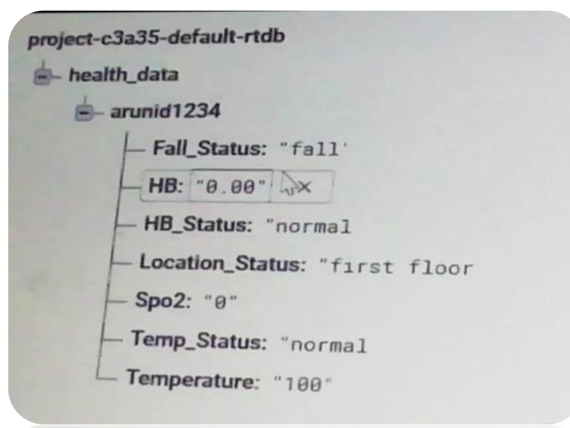

Figure 3.2.2

3.3. Requirement analysis and specification:

3.3.1. Input requirements:

1. **Arduino nano**

   Arduino Nano is one type of microcontroller board, and it is designed by Arduino.cc. This microcontroller is also used in Arduino UNO. It is a small size board and also flexible with a wide variety of applications

2. **ESP8266**

   The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all WiFi networking functions from another application processor.

3. **Spo2**

   A pulse oximeter noninvasively measures the oxygen saturation of a patient's blood. This device consists of a red and an infrared light source, photo detectors, and a probe to transmit light through a translucent, pulsating arterial bed, typically a fingertip or earlobe.

4. **Speaker**

   Speakers are one of the most common output devices used with computer systems. Speakers are transducers that convert electromagnetic waves into sound waves. The speakers receive audio input from a device such as a computer or an audio receiver.

5. **Location tracker**

   Location tracking refers to technologies that physically locate and electronically record and track the movement of people or objects. Location tracking technology is in use every day with GPS navigation, locations located on digital pictures and searching for businesses nearby using common apps.

6. **ADX – Average Directional Index**

   The MPU 6050 is a 6 DOF (Degrees of Freedom) or a six axis IMU sensor, which means that it gives six values as output. Three values from the accelerometer and three from the gyroscope. The MPU 6050 is a sensor based on MEMS (Micro Electro Mechanical Systems) technology.

7. **Compiler: Arduino IDE**

   The Arduino IDE is the combination of the Processing Language and Wiring Language framework. It's a cross-platform application that is used to write and upload codes in controller compatible boards.

3.3.2. Output requirements:

System with the basic requirements and a stable internet connection.

3.4. Technology stack:

Hardware Component

1) Spo2 Sensor

   The purpose of pulse oximetry is to check how well your heart is pumping oxygen through your body. It may be used to monitor the health of individuals with any type of condition that can affect blood oxygen levels.

2) Esp8266 Board

The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having TensilicaXtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs.

3) Location Tracker(Bluetooth)

Location Tracking (GPS) Tracking refers to a Global Positioning System. It entails a network of 24 satellites in orbit and devices on the ground that can establish a person or object's location on Earth with astonishing precision. GPS Tracking tracks three separate data sets: positioning, navigation, and timing.

4) Speaker

peakers are one of the most common output devices used with computer systems. Some speakers are designed to work specifically with computers, while others can be hooked up to any type of sound system. Regardless of their design, the purpose of speakers is to produce audio output that can be heard by the listener.

5) Adx –Average Directional Index (Sensor-Mpu6050)

The MPU6050 consist of 3-axis Gyroscope with Micro Electro Mechanical System(MEMS) technology. It is used to detect rotational velocity along the X, Y, Z axes

6) Lm35 (Temperature) Sensor

LM35 is a precession Integrated circuit Temperature sensor, whose output voltage varies, based on the temperature around it. It is a small and cheap IC which can be used to measure temperature anywhere between -55°C to 150°C. It can easily be interfaced with any Microcontroller that has ADC function or any development platform like Arduino.

Software Component

1) Firebase Google Server

Google Firebase is a Google-backed application development software that enables developers to develop iOS, Android and Web apps. Firebase provides tools for tracking analytics, reporting and fixing app crashes, creating marketing and product experiment.

2) Compiler- Arduino IDE

The Arduino IDE is the combination of the Processing Language and Wiring Language framework. It’s a cross-platform application that is used to write and upload codes in controller compatible boards.

4. System design:

4.1. ER diagram:

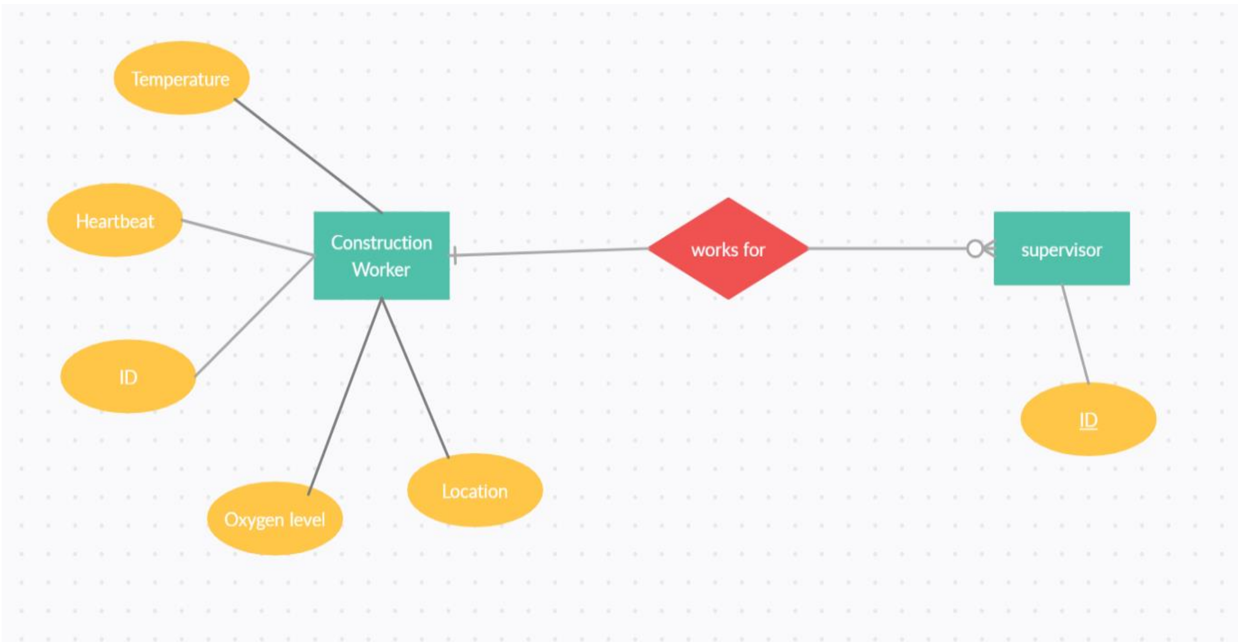

Figure 4.1.1

4.2. Data dictionary:

FIELD NAME	DATA TYPE	DESCRIPTION	EXAMPLE
Fall Status	String	To determine if the person has fallen down	“normal”
HB	Float	Heartbeat rate	80.38
HB_Status	String	Status of the heart beat	“normal”
Location_Status	String	Location of the user	“second_floor”
SPO2	Int	Oxygen level in the blood	93

Temp_status	String	Status of the body's temperature	"normal"
Temperature	float	Body's temperature	"33.00"

Table 4.2.1

4.3. UML Diagrams:

4.3.1.Use case diagram:

A Use case Diagram is used to present a graphical overview of the functionality provided by a system in terms of actors, their goals and any dependencies between those use cases. Use case diagram consists of two parts,

Use case: A use case describes a sequence of actions that provided something of measurable value to an actor and is drawn as a horizontal ellipse.

Actor: An actor is a person, organization or external system that plays a role in one or more interaction with the system.

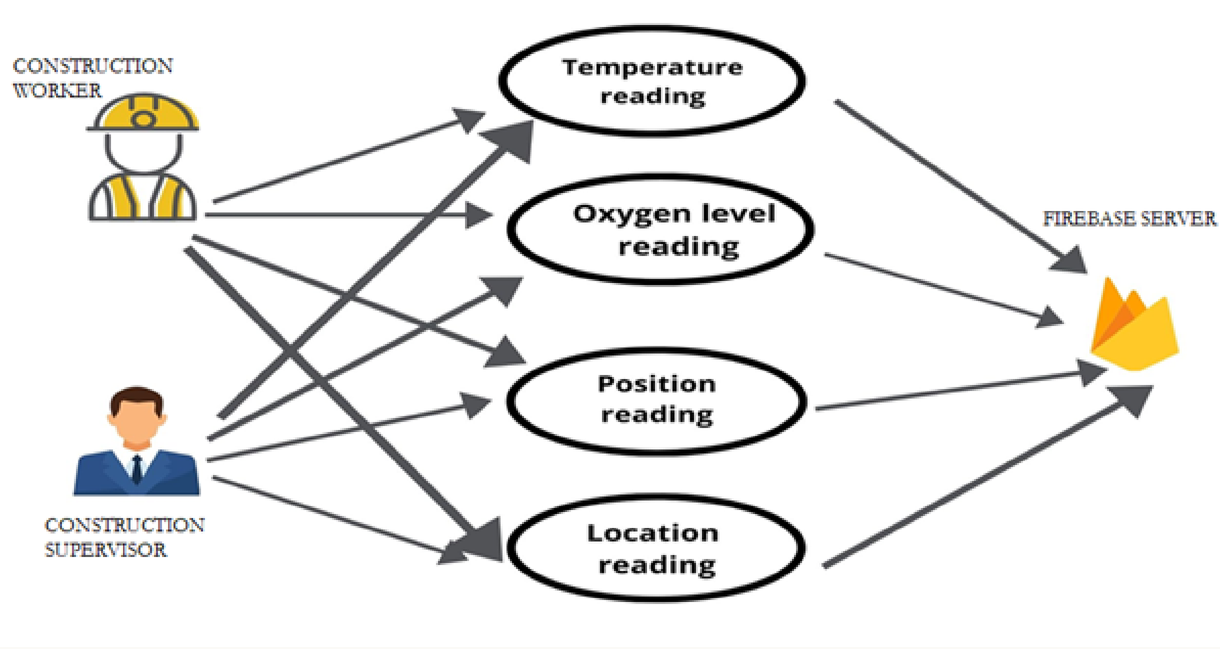

Figure 4.3.1

4.3.2.State Diagram:

A state diagram is used to represent the condition of the system or part of the system at finite instances of time. It’s a behavioral diagram and it represents the behavior using finite state transitions. State diagrams are also referred to as state machines and state-chart diagrams.

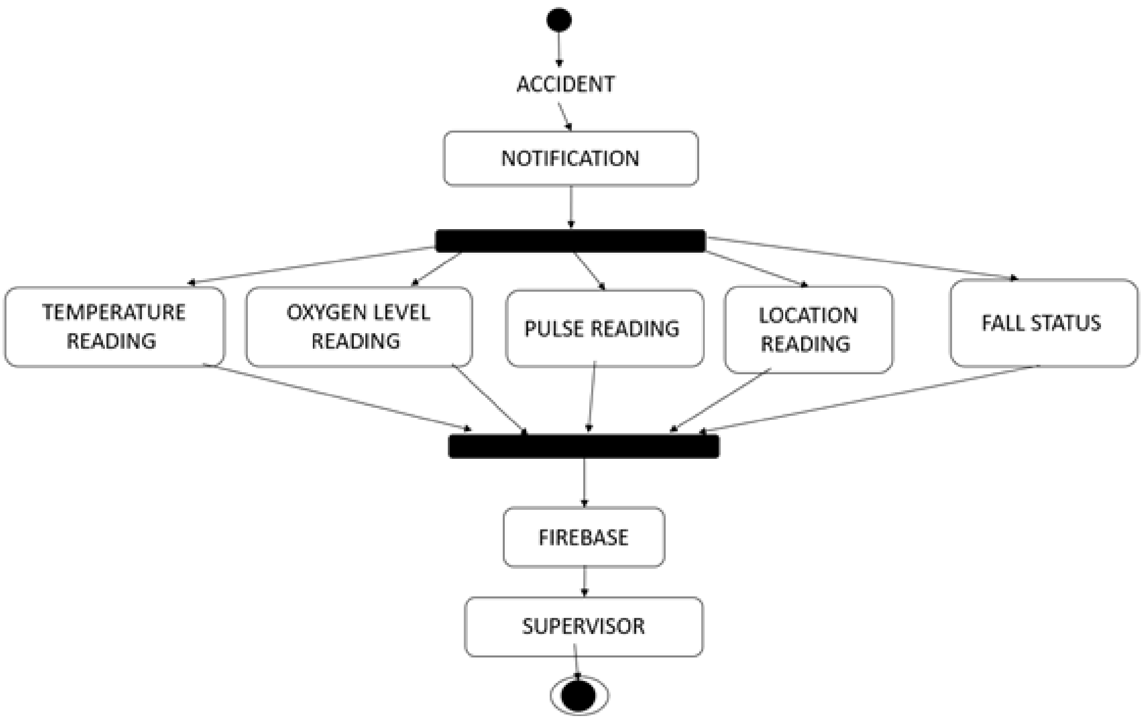

Figure 4.3.2

4.3.3.Activity diagram:

Activity diagram is a graphical representation of workflows of stepwise activities and actions with support for choice, iteration and concurrency. An activity diagram shows the overall flow of control.

The most important shape types:

- Rounded rectangles represent activities.
- Diamonds represent decisions.
- Bars represent the start or end of concurrent activities.

- A black circle represents the start of the workflow.
- An encircled circle represents the end of the workflow.

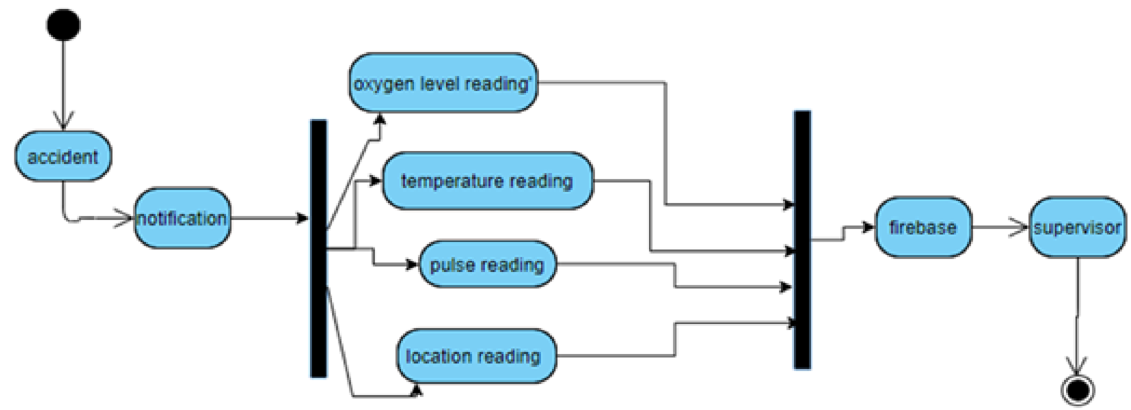

Figure 4.3.3

4.3.4.Sequence Diagram:

A Sequence diagram is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of Message Sequence diagrams are sometimes called event diagrams, event sceneries and timing diagram.

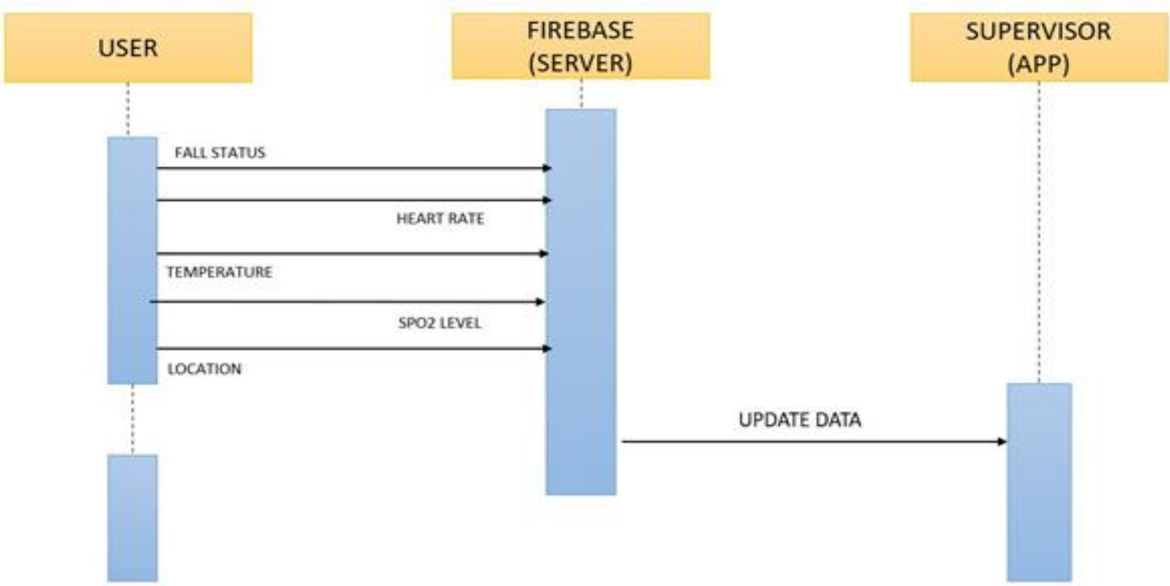

Figure 4.3.4

4.3.5.Collaboration diagram:

UML Collaboration Diagrams illustrate the relationship and interaction between software objects. They require use cases, system operation contracts and domain model to already exist. The collaboration diagram illustrates messages being sent between classes and objects.

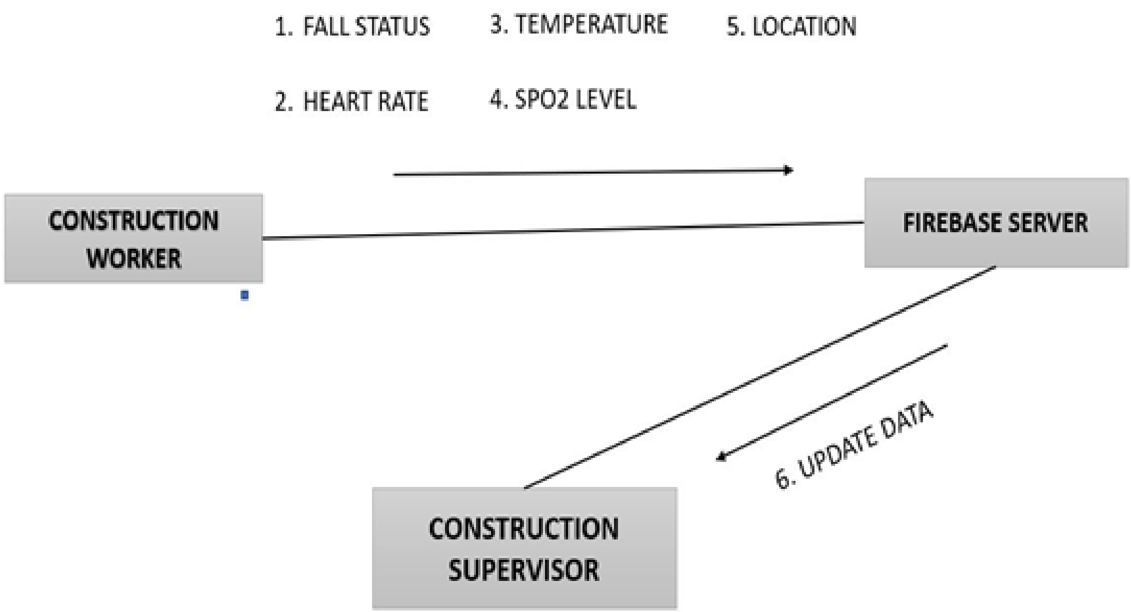

Figure 4.3.5

5. System architecture:

5.1. Architecture overview:

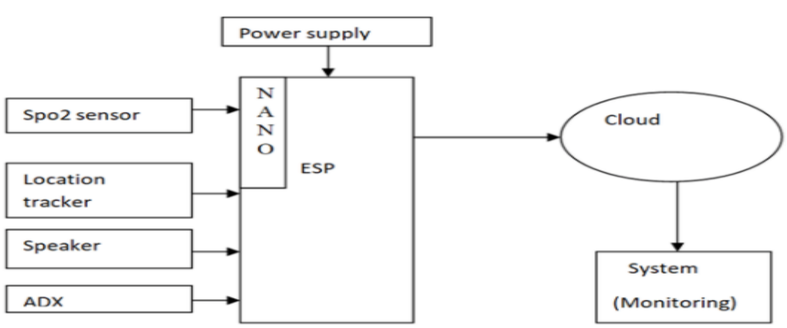

Figure 5.1.1

The above block diagram containsa spo2 sensor, location tracker, speaker, Arduino nano, esp8266 and ESP8266. Spo2 is connected to Arduino nano by using I2C protocol. Location tracker is connected to ESP 8266 by using UART protocol. Speaker connected to GPIO pin of ESP8266.

1. MAX30100 with Arduino uno:

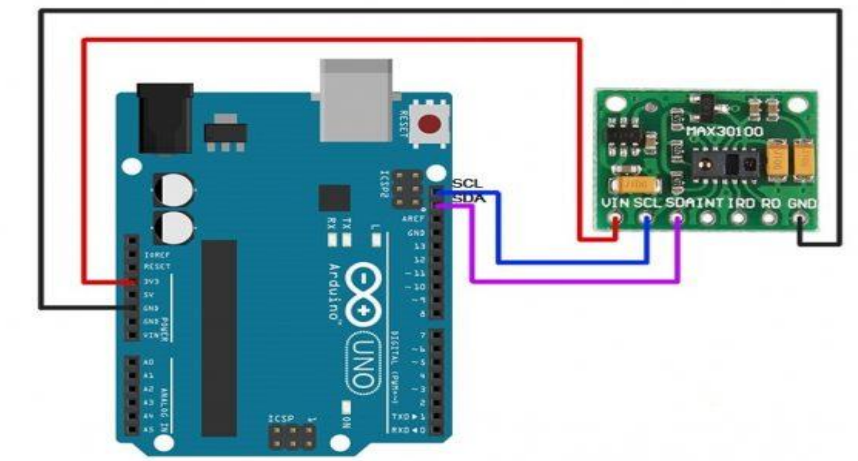

Figure 5.1.2

First, let me try to explain how the MAX30100 measures pulse rate. The device has two LEDs, one emitting a red light, another emitting infrared light. For pulse rate, only the infrared light is needed. Both the red light and infrared light is used to measure oxygen levels in the blood. More on that later.

When the heart pumps blood, there is an increase in oxygenated blood as a result of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. Ultimately, by knowing the time between the increase and decrease of oxygen-rich blood, the device calculates the pulse rate.

It turns out, oxygenated blood absorbs more infrared light and passes more red light while deoxygenated blood absorbs red light and passes more infrared light.

This is the main function of the MAX30100: it reads the absorption levels for both light sources and stored them in a buffer that can be read via I2C.

Purple MAX30100 Module	**Arduino UNO/Nano**
VIN	5V
GND	GND
SCL	A5
SDA	A4
INT	D2

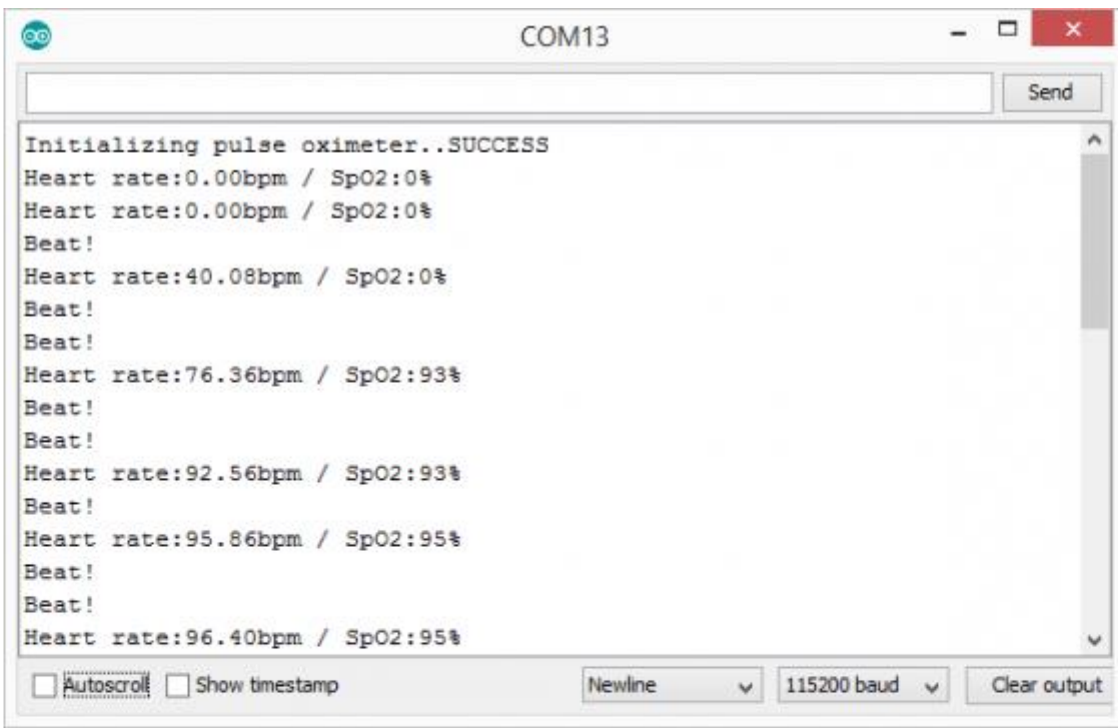

Figure 5.1.3

2. LM35 with Arduino uno:

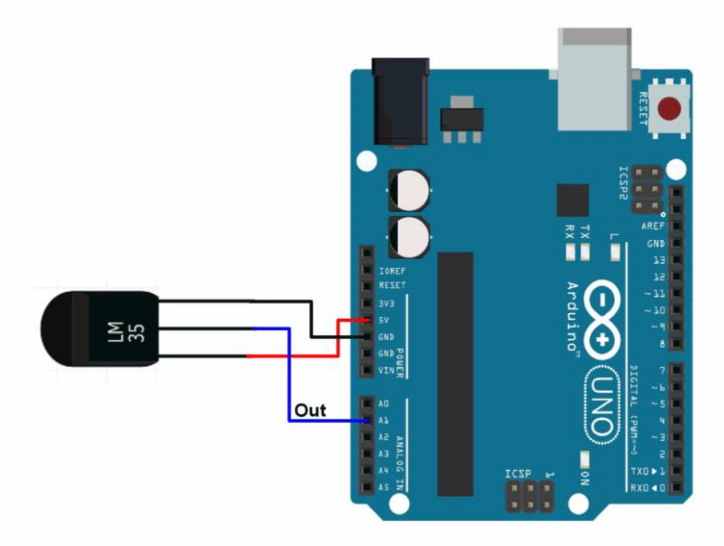

Figure 5.1.4

Let's start making the circuit. Remove the USB cable from the Arduino before starting this project. First, place the LM35 anywhere horizontally on your breadboard, the flat side of the sensor must be facing you. Then, connect three wires under the three pins of the sensor. The wire on the left will go to the 5v (+5volts) on the Arduino. The middle wire will go to A1 (analog pin 1). The wire on the right will go to GND (-) on the Arduino. Upload the code and open the serial monitor as readings of the temperature is shown. Make sure that the serial monitor is on 9600 bauds.

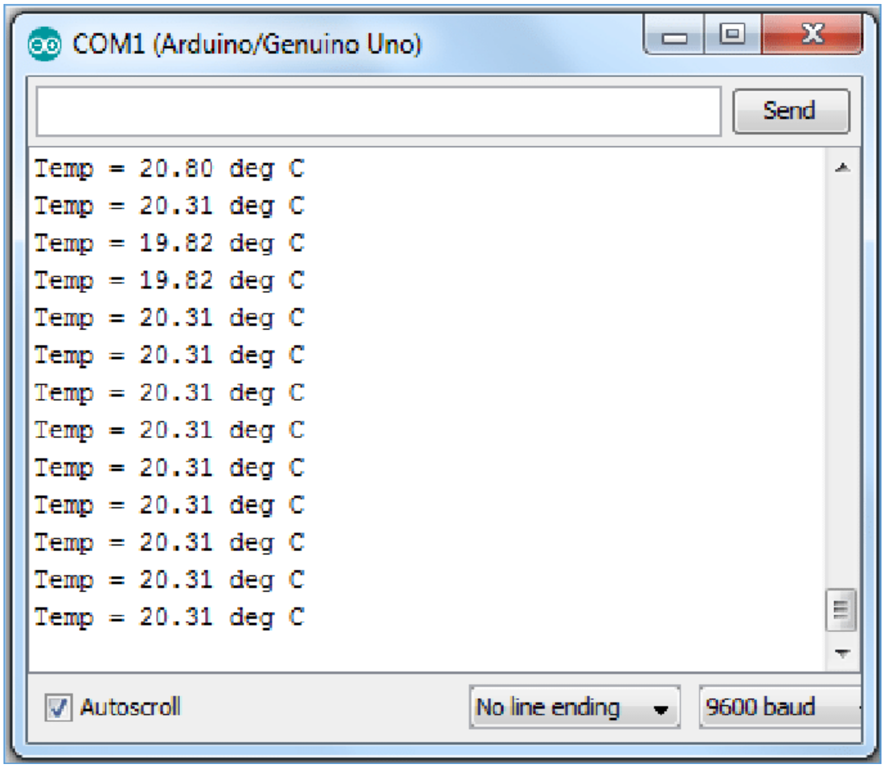

Figure 5.1.5

3. ESP8266 with ADXL345:

The **ADXL335 / GY-61** is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs.The product measures acceleration with a minimum full-scale range of ±3 g.It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

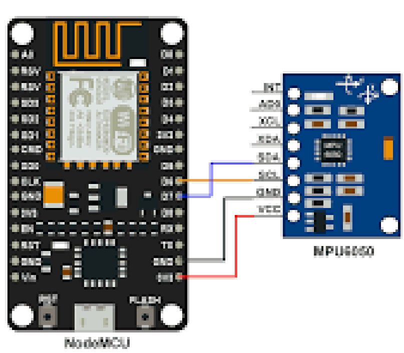

Figure 5.1.6

There is no on-board regulation, provided power should be between 1.8 and 3.6VDC.In general, **ADXL335** is 3v3 compatible device; it's powered by a 3.3v source and also generates 3.3v peak outputs. It has three outputs for each axis, i.e.**X**, **Y**&**Z**. These are analog outputs and thus require an ADC in a micro-controller. **NodeMCU** solves this problem. We will be using the analog pin of **NodeMCU**.

The **Accelerometer** module has **5 pins** i.e.,

VCC - To be connected to NodeMCU +**3.3v**.

X - To be connected to Analog Pin **A0** of the NodeMCU.

Y - NIL

Z - NIL

GND - To be connected to Ground Pin (**GND**) of the NodeMCU.

<u>Note</u> : Since NodeMCU has only one Analog Pin, you can connect either of X, Y, or Z pin to it.

Before you get started with coding you need Arduino IDE.To download Arduino IDE and for NodeMCU setup, you can check my previous instructacle.

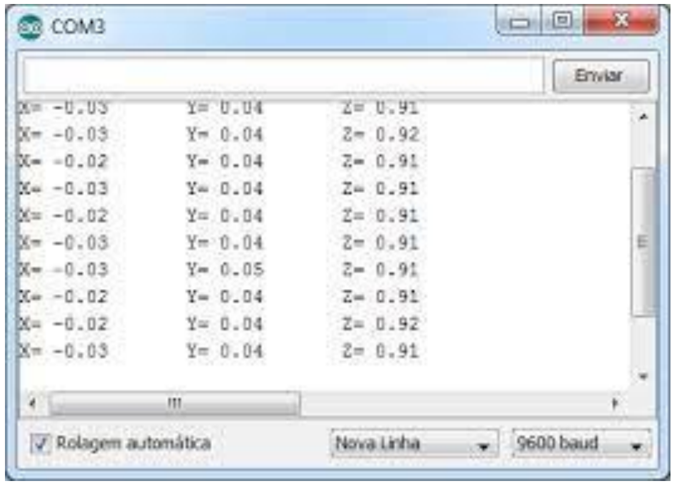

Figure 5.1.7

5.2. Module design specification:

. There are five different modules present in our product are

1. Fall Detection Module,
2. Temperature Sensing Module,
3. Oxygen Level Sensing Module,
4. Location and Position Sensing Module
5. Heart Rate Detection Module.

Fall detection module:

This module consists of a tiny self-assembled sensor unit which is used to calculate the angular velocity of an object and the human body's motion or acceleration. A single chip has both an accelerometer and a gyroscope embedded into it. This chip is then fixed inside the kit. It detects the axis, gravity and acceleration. They aid us in detecting falls caused due to fatigue, drowsiness, etc. The APP uses the axis to detect if a fall has taken place, by using the fall detection algorithm. As soon as a fall is detected, the contractor is notified. For our system the power supply is provided by connecting the kit to the laptop but we can attach a battery with 3.5 -5 volts in future, ensuring that it will be easy for the users to carry it around.

Figure 5.2.1

Temperature sensing module:

The temperature sensor senses the temperature of the construction worker who is wearing the device. The threshold value for this temperature sensor is 80. It helps in determining if a construction worker is sick or not.

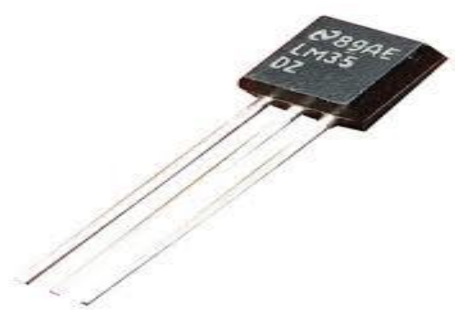

Figure 5.2.2

Oxygen Level Sensing Module:

This module will be used to measure if the respiratory systems are working or not. It measures the amount of oxygen present in the blood of a worker, and so will be useful in finding the worker is alive and healthy after an untoward accident takes place.

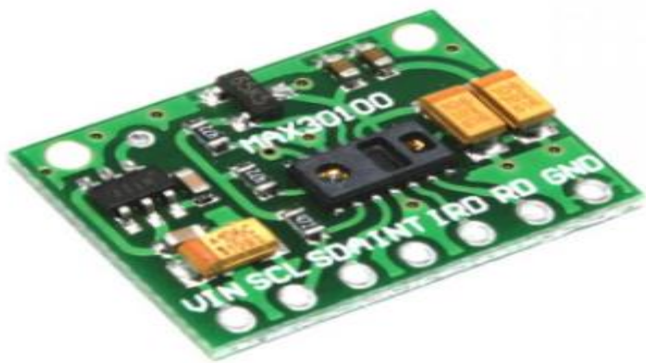

Figure 5.2.3

Location and Position Sensing Module:

Location sensor to find out the location of a particular worker is present using unique ID, Eg: Worker ID 8266 is in 1st floor. It also help to check in groups - The number of people working at a particular floor at a particular time. Position sensor will be useful to determine the number of people who are stuck in event of accident.

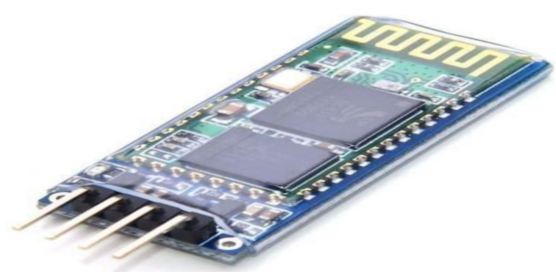

Figure 5.2.4

Heart Rate Detection Module:

This sensor is used to find out the rate of heartbeat of a particular user (Construction Worker). In a event of disaster this sensor is used to determine whether the worker is still alive or not to proceed with evacuation.

Figure 5.2.5

SPO2 sensor

The LED's present in this sensor, shines the light through the tissues, and the sensor present on the other side, finds out the amount of light which is transferred through the tissues to find out the amount of oxygen present in the blood stream.

6. System implementation:

6.1. Client side coding:

```
#include "MAX30100_PulseOximeter.h"
#define REPORTING_PERIOD_MS     1000

PulseOximeter pox;
uint32_t tsLastReport = 0;
 int temp,x,y,z;
 int q=0;
 int Reset = 4;
 int led =10;
void onBeatDetected()
{
   //Serial.println("Beat");
}

void setup()
{
Serial.begin(115200);
   //Serial.print("Initializing pulse oximeter..");
digitalWrite(Reset, HIGH);
delay(200);
pinMode(Reset, OUTPUT);
pinMode(led, OUTPUT);
digitalWrite(led,HIGH);
delay(1000);
```

```
digitalWrite(led,LOW);
   if (!pox.begin()) {
     // Serial.println("FAILED");
for(;;);
   } else {
      // Serial.println("SUCCESS");
   }
pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
pox.setOnBeatDetectedCallback(onBeatDetected);
}

void loop()
{
   temp=analogRead(A0);
   x=analogRead(A1);
   y=analogRead(A2);
   z=analogRead(A3);

pox.update();
   if (millis() - tsLastReport> REPORTING_PERIOD_MS) {
       /*Serial.print("BP:");
Serial.print(pox.getHeartRate());
Serial.print("/");
Serial.print("SPO2:");
Serial.print(pox.getSpO2());
Serial.print("/");*/
      float mv = ( temp/1024.0)*5000;
```

```
        float cel = mv/10;
cel=random(29,34);
        /*Serial.print("Temp:");
Serial.print(cel);
Serial.print("/");

Serial.print("y:");
Serial.println(y);
Serial.print("z:");
Serial.println(z);*/
        if(q==9){

Serial.println("~"+String(pox.getHeartRate())+"!"+String(pox.getSpO2())+"@"+St
ring(cel)+"#");
          q=0;
        }
        q++;
tsLastReport = millis();
    }
}
```

6.2. Server side coding:

```
#include <SoftwareSerial.h>
#include "FirebaseESP8266.h"
#include <ESP8266WiFi.h>
#include <Wire.h>
```

```
// ADXL345 I2C address is 0x53(83)
#define Addr 0x53
int pin =2;

const uint8_t scl = 14; //D5
const uint8_t sda = 12; //D6

float xAccl, yAccl, zAccl;
#define FIREBASE_HOST "project-c3a35-default-rtdb.firebaseio.com"
#define FIREBASE_AUTH
"Tnf476oGSBRXZKmfpIZtSGLmDoLvnMVmH5opOTEb"
#define WIFI_SSID "iotkit"
#define WIFI_PASSWORD "123456789"
FirebaseDatafirebaseData;
float r,r1,r2;
SoftwareSerialBTSerial(5, 4);
int i1,i2,b,b1,b2,b3,b4,b5;
String smsg1,smsg2;
String S,S1,S2,S3,S4,S5,S6,S7,S8,S9,json1,json2,json3,json4;
String data1;
int data,data2,value,temp,val2;
int pin1 =2;
void setup(void)
{
Serial.begin(115200);
bluetooth();
Wire.begin(sda, scl);
```

```
pinMode(pin1,OUTPUT);
digitalWrite(pin1,LOW);
WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
    while (WiFi.status() != WL_CONNECTED)
    {
Serial.print(".");
delay(300);
   }
Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
Firebase.reconnectWiFi(true);
  {
Serial.println("----------Begin Set Test-----------");
  }
}
void handleroot()
{
 unsigned int data[6];

 // Start I2C Transmission
Wire.beginTransmission(Addr);
 // Select bandwidth rate register
Wire.write(0x2C);
 // Normal mode, Output data rate = 100 Hz
Wire.write(0x0A);
 // Stop I2C transmission
Wire.endTransmission();
```

```
  // Start I2C Transmission
Wire.beginTransmission(Addr);
  // Select power control register
Wire.write(0x2D);
  // Auto-sleep disable
Wire.write(0x08);
  // Stop I2C transmission
Wire.endTransmission();

  // Start I2C Transmission
Wire.beginTransmission(Addr);
  // Select data format register
Wire.write(0x31);
  // Self test disabled, 4-wire interface, Full resolution, Range = +/-2g
Wire.write(0x08);
  // Stop I2C transmission
Wire.endTransmission();
delay(300);

  for (int i = 0; i< 6; i++)
  {
    // Start I2C Transmission
Wire.beginTransmission(Addr);
    // Select data register
Wire.write((50 + i));
    // Stop I2C transmission
Wire.endTransmission();
```

```
   // Request 1 byte of data
Wire.requestFrom(Addr, 1);

   // Read 6 bytes of data
   // xAccllsb, xAcclmsb, yAccllsb, yAcclmsb, zAccllsb, zAcclmsb
   if (Wire.available() == 1)
   {
     data[i] = Wire.read();
   }
  }

  // Convert the data to 10-bits
  int xAccl = (((data[1] & 0x03) * 256) + data[0]);
  if (xAccl> 511)
  {
xAccl -= 1024;
  }
  int yAccl = (((data[3] & 0x03) * 256) + data[2]);
  if (yAccl> 511)
  {
yAccl -= 1024;
  }
  int zAccl = (((data[5] & 0x03) * 256) + data[4]);
  if (zAccl> 511)
  {
zAccl -= 1024;
```

```
  }

  // Output data to serial monitor
Serial.print("Acceleration in X-Axis : ");
Serial.println(xAccl);
Serial.print("Acceleration in Y-Axis : ");
Serial.println(yAccl);
Serial.print("Acceleration in Z-Axis : ");
Serial.println(zAccl);
delay(300);
 if(yAccl<80)
    {
     S8="fall";
digitalWrite(pin1,HIGH);
delay(1000);
digitalWrite(pin1,LOW);
}else {
      S8="normal";
    }

}

void loop(void)
{
handleroot();
BTSerial.println("AT+INQ");
delay(1000);
```

```
smsg1 = BTSerial.readStringUntil('\n');
//Serial.println(smsg1);
for(int i=5;i<16;i++)
{
 smsg2+=smsg1[i];
}

if(smsg2=="13:EF:7A8,1"){
  S9="secon_floor";
Serial.println(S9);
}
Serial.println(smsg2);
if(Serial.available())
{
 S=Serial.readStringUntil('\n');
Serial.println(S);
 int a6=S.indexOf("~");
 int a1=S.indexOf("!");
 int a2=S.indexOf("@");
 int a3=S.indexOf("#");

 S5=S.substring(a6+1, a1);
 S1=S.substring(a1+1, a2);
 S2=S.substring(a2+1, a3);
Serial.println(S5);
Serial.println(S1);
Serial.println(S2);
```

```
 b=S5.toInt();
 b1=S1.toInt();
 b2=S2.toInt();
 if((b>90 || b<50)&& b>30){
  S6="emergency";
}else {
  S6="normal";
 }
 if(b2>38){
  S7="High";
}else {
  S7="normal";
 }

Firebase.setString(firebaseData,"/health_data/arunid1234/HB",S5);
 Firebase.setString(firebaseData,"/health_data/arunid1234/Spo2",S1);
 Firebase.setString(firebaseData,"/health_data/arunid1234/Temperature",S2);
 Firebase.setString(firebaseData,"/health_data/arunid1234/HB_Status",S6);
 Firebase.setString(firebaseData,"/health_data/arunid1234/Temp_Status",S7);
 Firebase.setString(firebaseData,"/health_data/arunid1234/Fall_Status",S8);
 Firebase.setString(firebaseData,"/health_data/arunid1234/Location_Status",S9);
 }

  smsg2="";
}
void bluetooth()
{
```

```
 // Serial.println("Enter AT commands:");
BTSerial.begin(38400);
BTSerial.println("AT");
delay(100);
BTSerial.println("AT+INIT");
delay(100);
BTSerial.println("AT+INQM=1,1,48");
delay(100);
}
```

7. System Testing:

7.1. Unit testing:

Heart rate:

```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"

#define REPORTING_PERIOD_MS     1000

// PulseOximeter is the higher level interface to the sensor
// it offers:
//  * beat detection reporting
//  * heart rate calculation
//  * SpO2 (oxidation level) calculation
PulseOximeter pox;

uint32_t tsLastReport = 0;

// Callback (registered below) fired when a pulse is detected
void onBeatDetected()
{
   Serial.println("Beat!");
}

void setup()
{
```

```
  Serial.begin(115200);

  Serial.print("Initializing pulse oximeter..");

  // Initialize the PulseOximeter instance
  // Failures are generally due to an improper I2C wiring, missing power supply
  // or wrong target chip
  if (!pox.begin()) {
    Serial.println("FAILED");
    for(;;);
  } else {
    Serial.println("SUCCESS");
  }

  // The default current for the IR LED is 50mA and it could be changed
  //   by uncommenting the following line. Check MAX30100_Registers.h for all
the
  //   available options.
  // pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

  // Register a callback for the beat detection
  pox.setOnBeatDetectedCallback(onBeatDetected);
}

void loop()
{
  // Make sure to call update as fast as possible
```

```
    pox.update();

    // Asynchronously dump heart rate and oxidation levels to the serial
    // For both, a value of 0 means "invalid"
    if (millis() - tsLastReport> REPORTING_PERIOD_MS) {
        Serial.print("Heart rate:");
        Serial.print(pox.getHeartRate());
        Serial.print("bpm / SpO2:");
        Serial.print(pox.getSpO2());
        Serial.println("%");

        tsLastReport = millis();
    }
}
```

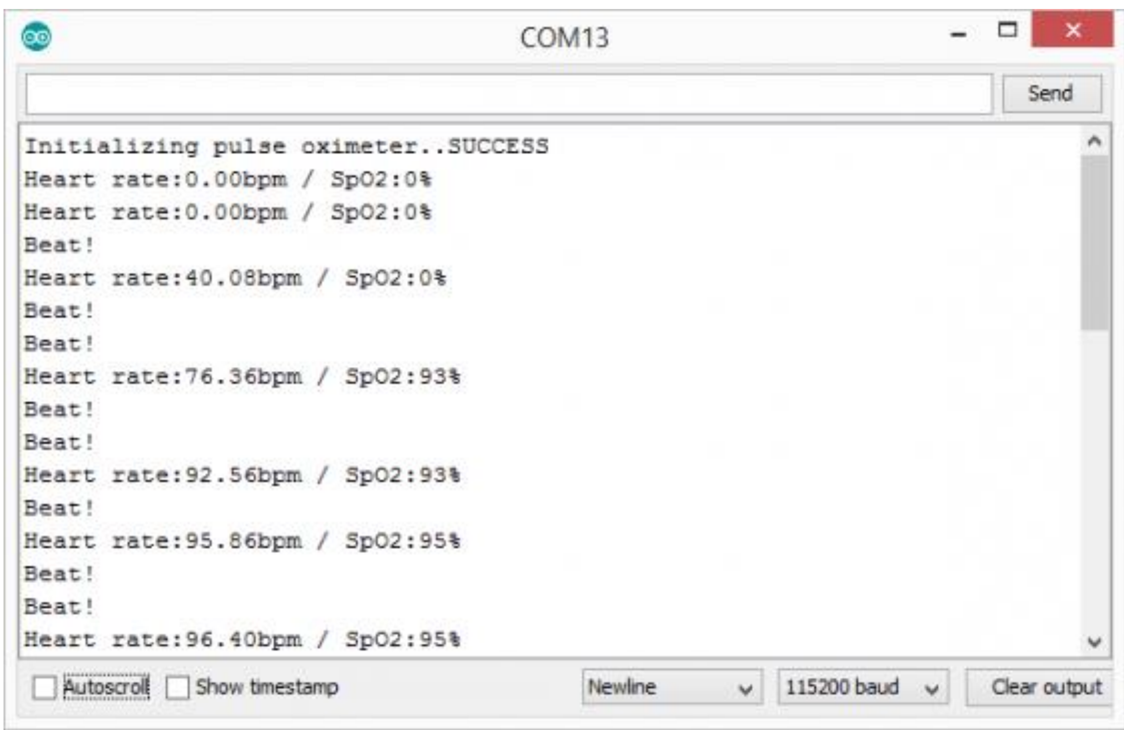

Figure 7.1.1

Temperature:

```
intval;
inttempPin=1;

voidsetup()
{
Serial.begin(9600);
}
voidloop()
{
val=analogRead(tempPin);
floatmv=(val/1024.0)*5000;
floatcel=mv/10;
floatfarh=(cel*9)/5+32;
Serial.print("TEMPRATURE = ");
Serial.print(cel);
Serial.print("*C");
Serial.println();
delay(1000);
/* uncomment this to get temperature in farenhite
Serial.print("TEMPRATURE = ");
Serial.print(farh);
Serial.print("*F");
Serial.println();
*/
}
```

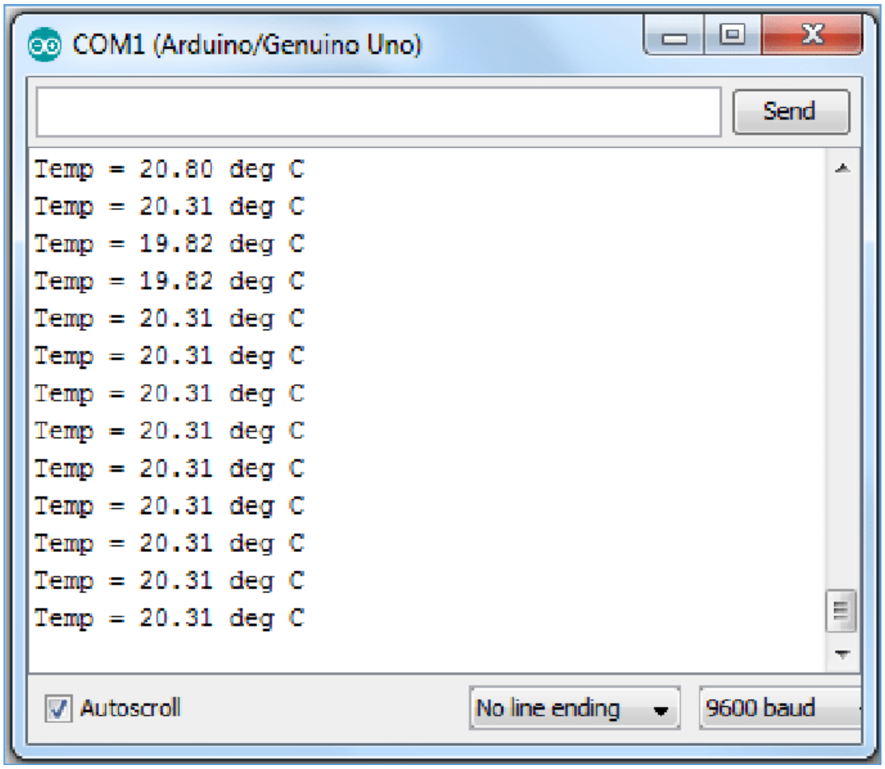

Figure 7.1.2

Axis:

```
#include
<ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
#include <Wire.h>
// ADXL345 I2C address is 0x53(83)
#define Addr 0x53
const uint8_t scl = 14; //D5
const uint8_t sda = 12; //D6
```

```
const char* ssid = "XXXXXX";
const char* password = "XXXXX";
float xAccl, yAccl, zAccl;
ESP8266WebServer server(80);
void handleroot()
{
unsigned int data[6];
// Start I2C Transmission
Wire.beginTransmission(Addr);
// Select bandwidth rate register
Wire.write(0x2C);
// Normal mode, Output data rate = 100 Hz
Wire.write(0x0A);
// Stop I2C transmission
Wire.endTransmission();
// Start I2C Transmission
Wire.beginTransmission(Addr);
// Select power control register
Wire.write(0x2D);
// Auto-sleep disable
Wire.write(0x08);
// Stop I2C transmission
Wire.endTransmission();
```

```
// Start I2C Transmission
Wire.beginTransmission(Addr);
// Select data format register
Wire.write(0x31);
// Self test disabled, 4-wire interface, Full resolution,
Range = +/-2g
Wire.write(0x08);
// Stop I2C transmission
Wire.endTransmission();
delay(300);
for (int i = 0; i< 6; i++)
{
// Start I2C Transmission
Wire.beginTransmission(Addr);
// Select data register
Wire.write((50 + i));
// Stop I2C transmission
Wire.endTransmission();
// Request 1 byte of data
Wire.requestFrom(Addr, 1);
// Read 6 bytes of data
// xAccllsb, xAcclmsb, yAccllsb, yAcclmsb, zAccllsb,
zAcclmsb
```

```
if (Wire.available() == 1)
{
data[i] = Wire.read();
}
}
// Convert the data to 10-bits
int xAccl = (((data[1] & 0x03) * 256) + data[0]);
if (xAccl> 511)
{
xAccl -= 1024;
}
int yAccl = (((data[3] & 0x03) * 256) + data[2]);
if (yAccl> 511)
{
yAccl -= 1024;
}
int zAccl = (((data[5] & 0x03) * 256) + data[4]);
if (zAccl> 511)
{
zAccl -= 1024;
}
// Output data to serial monitor
Serial.print("Acceleration in X-Axis : ");
```

```
Serial.println(xAccl);
Serial.print("Acceleration in Y-Axis : ");
Serial.println(yAccl);
Serial.print("Acceleration in Z-Axis : ");
Serial.println(zAccl);
delay(300);


}
void setup()
{
// Initialise I2C communication as MASTER
Wire.begin(sda, scl);
// Initialise serial communication, set baud rate = 115200
Serial.begin(115200);
// Connect to WiFi network
WiFi.begin(ssid, password);
// Wait for connection
while (WiFi.status() != WL_CONNECTED)
{
delay(500);
Serial.print(".");
}
```

```
Serial.println("");
Serial.print("Connected to ");
Serial.println(ssid);
// Get the IP address of ESP8266
Serial.print("IP address: ");
Serial.println(WiFi.localIP());
// Start the server
server.on("/", handleroot);
server.begin();
Serial.println("HTTP server started");
}
void loop()
{
server.handleClient();
}
```

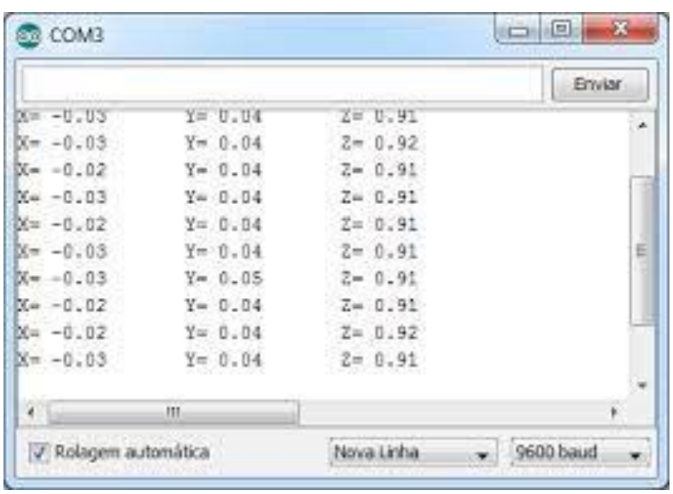

Figure 7.1.3

7.2. Integration testing:

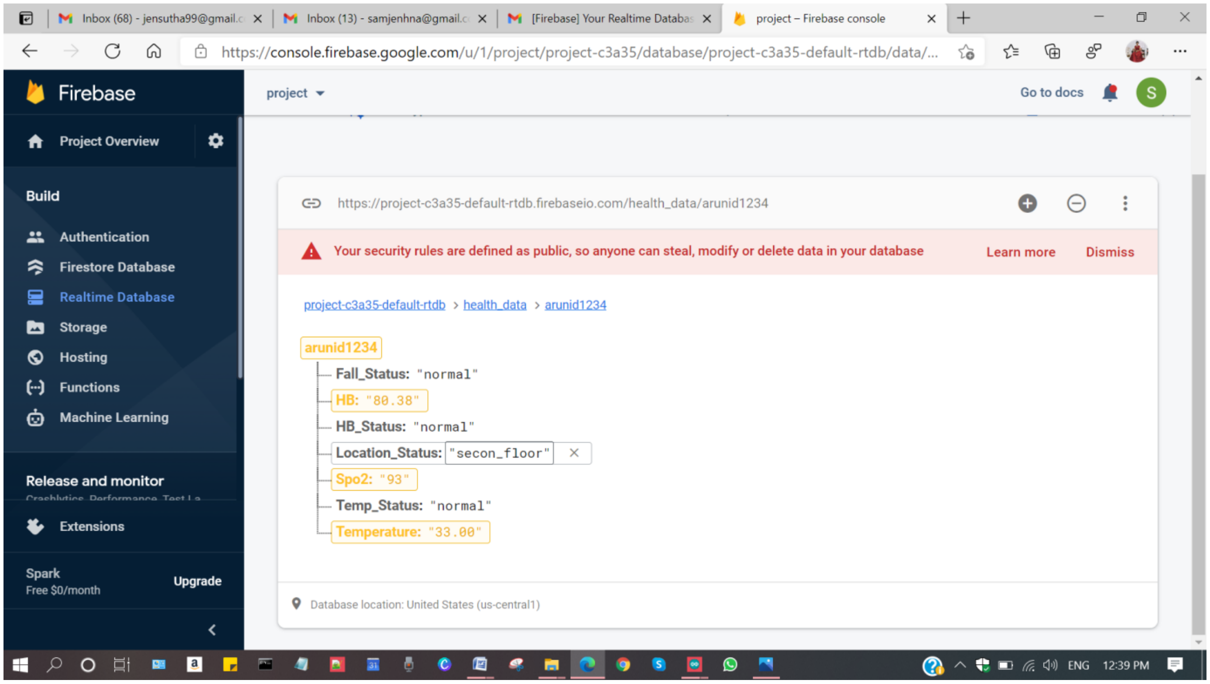

Figure 7.2.1

7.3. Performance analysis:

In the literature, there are already many works for human fall detection. To address the advantages of our method, we make a comparison with some previous methods in terms of sensor location, accuracy, portability, and comfort. Though the experiment protocols of these methods are different and the datasets for detection are based on their experiments, all of them considered the distinction between simulated falls.Meanwhile, our system has good portability because the small sensor safety kit can easily be worn by a worker.Our system also includes a unique feature which is the heart rate monitor which would be highly useful in determining whether the worker is alive or not in event of disaster and help in prioritizing which worker to save first during the excavation process. The position detector would help in locating the worker in event of disaster. It would pin-point which floor the worker was in before the fall which would help us determine how many feet under he is.

The result analysis of our project includes

1) sensing the fall of a worker , temperature, position, heart rate and oxygen level by the smart kit

2)Transmission of data using Wi-Fi to Firebase

3) Storing and monitoring data using our app.

8. Conclusion:

8.1. Conclusion and future enhancements:

If this proposed system is implemented then it would **ensure the complete safety** of the workers at the construction site. Through this smart kit, the contractor can **continuously monitor** all the workers involved in the construction process and can also get notified about the workers' physical condition and can immediately save the workers from any serious issues in case of emergency. Hence we can reduce the death rate of the construction workers and provides increased security to them.

This application would play an important role in **rescue process** at a faster pace, thus ensuring that many **valuable lives are saved** from the clutches of suffocation and eventual death. Since there are **no products** designed with our unique features at present - to help reduce the number of deaths in the construction field, our product will be **one in a kind**.

Appendices:

A.1. Sample screens:

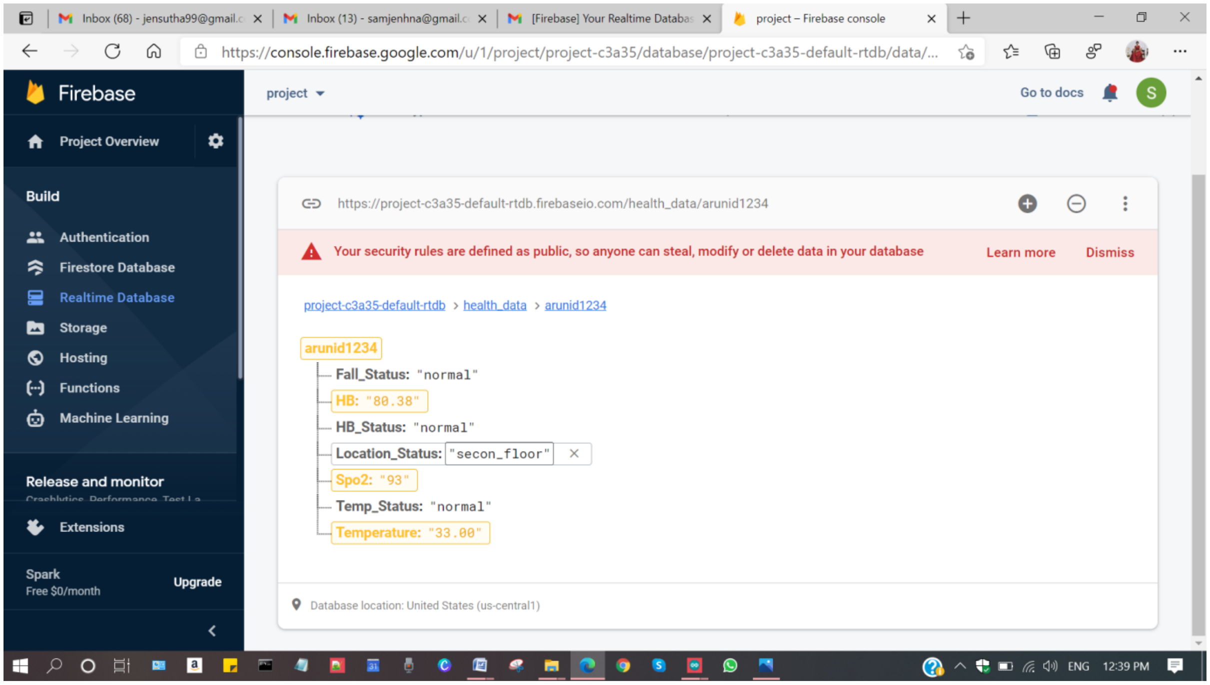

Figure A.1.1

A.2. Publication:

This project was presented as a paper at the Fourth International Conference on Intelligent Computing held at Panimalar Engineering College on 27.03.2021, by Jenifer.S, Sudharshna.U, Sameera.H and Devi.R.

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Certificate of Participation

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This is to certify that Dr./Mr./Ms **Jenifer.S** of CSE from **Panimalar Engineering college** has presented paper entitled IOT BASED SAFETY KIT FOR CONSTRUCTION WORKERS in the **4th International Conference on Intelligent Computing (IConIC)** held on 26th & 27th March 2021.

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IEEE MADRAS SECTION

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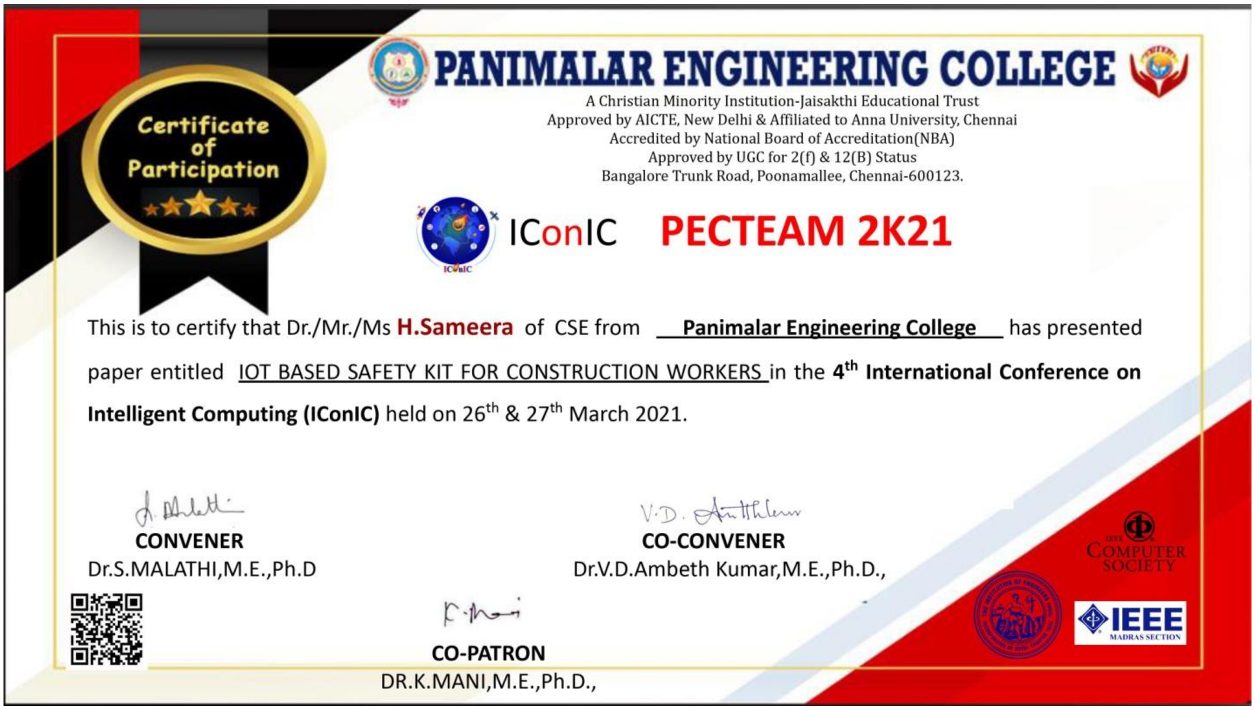
CO-PATRON
DR.K.MANI,M.E.,Ph.D.,

COMPUTER SOCIETY

IEEE MADRAS SECTION



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PAPER PRESENTED:

FOURTH INTERNATIONAL CONFERENCE ON INTELLIGENT COMPUTING

IOT BASED SAFETY KIT FORCONSTRUCTION WORKERS

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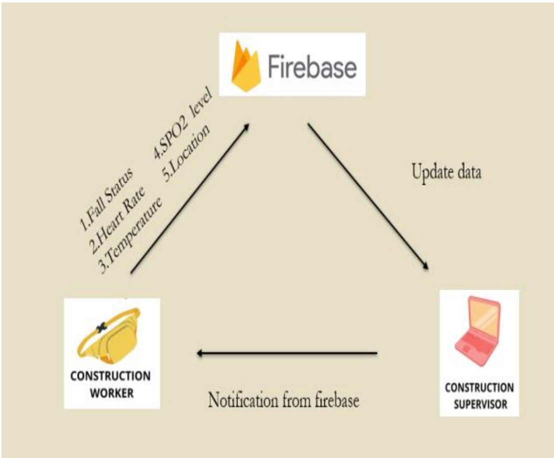
Abstract:

The Indian Institute of Technology (IIT) conducted a survey and found out that about 48,000 workers die every year in the due to accidents which occur in their occupation, that is approximately equal to around 38 workers losing their lives every day, and 38 families losing the sole bread earner of their families. India has a total population of 138 crore and a total workforce of 46.5 crore, so a sum of approximately 46 crore people are in a need of a solution to this grave danger which they face every day. There are no products designed at present to help reduce the number of deaths in the construction field, so our product will be one in a kind. A handy IOT based safety kit is designed for the construction workers. Each kit has a unique ID, and is to be worn at all times by the workers, when they are on – site. If an accident occurs on the site causing the user to get stuck between a mass of debris, this kit will be instrumental in the rescue process.

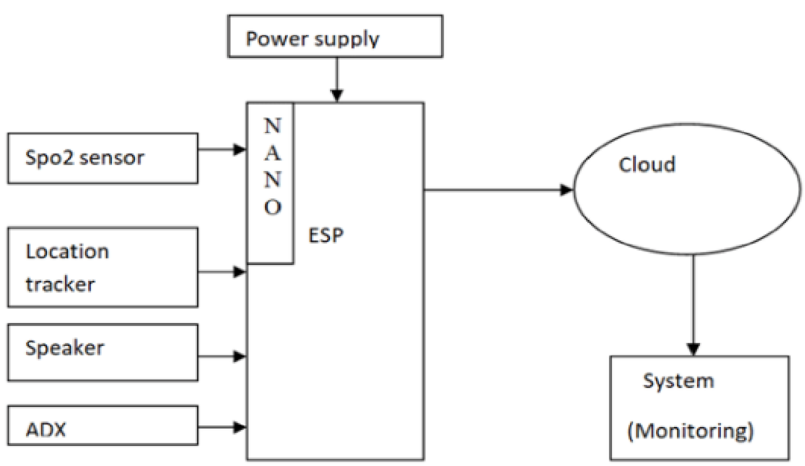
I Introduction:

Internet of things is a set of connections of many sensors and modules. In our proposed product, this network of things help the supervisors in the construction field in daily life and especially during rescue missions if any untoward accident occurs to the construction workers, on the site.



A research paper "An estimate of fatal accidents in Indian construction" by Dilip kumar Patel and Kumar Neeraj Jha reports that every year 24.20% of the deaths occurring at occupational sites are caused by the construction industry, causing it to be the highest in the nation every year. It is also reported that about 80% of the construction sites in India are unsafe. The British Safety Council, an organization committed to safety at the place of work, has declared officially that there is only one overseer for every 500 factories.

This shows that, some sort of protective measures need to be taken by the construction workers while working in the site. If the workers wear our device while working everyday, it will be useful in the longer run, and a peace of mind can be achieved in the knowledge that if anything goes wrong, quick measures can be taken during the rescue process.



II Literature Survey

1.Pulishetty Prasad et all proposed a system "Zigbee Based Intelligent Helmet For Coal Miners" in 2017. It discovers real time monitoring with timely warning intelligence when there is a leakage of gas, rise or drop in temperature and informs control station by using new age Zigbee wireless technology. This system helps in pointing the location of a person accurately and covers a massive area. The major disadvantage of this system is that it is particularly focused on workplace safety rather on workers.

2.Mangala Nandhini. V et all proposed a system "IOT based Smart Helmet for Ensuring Safety in Industries" in 2018.This system provides actual timedetection of threatening gases like CO,CH4, LPG , temperature and humidity and provides emergency alert to the control station. Wi-Fi is used to transfer data from the helmet to the monitoring station. The reliability and durability of the communication system is poor.

3.Raghavendra Rao B et all proposed a system "'SIRASTRANA': A Smart Helmet for Air Quality and Hazardous Event Detection for the Mining Industry "in 2018.In the event of miners struck by a hard rock or any object on their heads with a force over a stated limit of 1000 on the HIC (Head Injury Criteria) the accelerometer alerts the monitoring station.Helmet Removal Sensor it alerts when the worker has removed the helmet during working hours. But this system does not provide any other protective measures in case of emergency conditions.

4. K.Divya et all proposed a system "A Smart Helmet For Improving Safety In Mining Industry" in 2017.In case of any poisonous gas detection the helmet provides oxygen by opening a valve. It detects hazardous event, monitors and provides oxygen supplements to avoid the inhalation of poisonous gases. The helmet is too heavy since it contains oxygen cylinders which is uncomfortable to work with.

5.C.Jagadeeswari et all proposed a system "Hard Hat Detection Using Deep Learning Techniques" in 2020.This system uses YOLO algorithm – a much faster algorithm in object identification to detect whether the worker is wearing the helmet during working or not. The main advantage of this system is that it protects the head which is the most crucial part of the body.But this system has a clear motive to protect only the head and does not provide any other support during emergency situation.

6. Jie Luo et all proposed a system "Highly Portable, Sensor-Based System for Human Fall Monitoring" in 2017.This system consists of a highly portable sensor unit including a triaxis accelerometer, a triaxis magnetometer, and a mobile phone and with the data from these sensors, systemobtains the acceleration and Euler angle (yaw, pitch, and roll), which represents the orientation of the user’s body. This system helps in fall detection and help in daily life of elders. It focuses onproviding safety for elderly people but not for the industrial workers.

III Proposed System:

Our proposed system is a small kit which comprises of the following components SPO2 sensor, ESP8266 board, location tracker (bluetooth), speaker, ADX–average directional index (sensor-MPU6050), LM35 (temperature) and Google firebase is used as the cloud platform. There are five different modules present in our product are

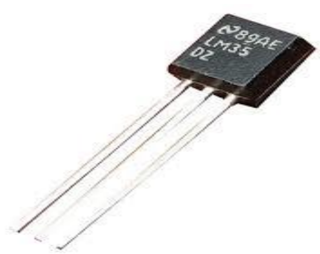
9. Fall Detection Module,
10. Temperature Sensing Module,
11. Oxygen Level Sensing Module,
12. Location and Position Sensing Module,
13. Heart Rate Detection Module.

Fall detection module:

This module consists of a tiny self-assembled sensor unit which is used to calculate the angular velocity of an object and the human body’s motion or acceleration. A single chip has both an accelerometer and a gyroscope embedded into it. This chip is then fixed inside the kit. It detects the axis, gravity and acceleration. They aid us in detecting falls caused due to fatigue, drowsiness, etc. The APP uses the axis to detect if a fall has taken place, by using the fall detection algorithm. As soon as a fall is detected, the contractor is notified. For our system the power supply is provided by connecting the kit to the laptop but we can attach a battery with 3.5 -5 volts in future, ensuring that it will be easy for the users to carry it around.

Temperature sensing module:

The temperature sensor senses the temperature of the construction worker who is wearing the device. The threshold value for this temperature sensor is 80. It helps in determining if a construction worker is sick or not.

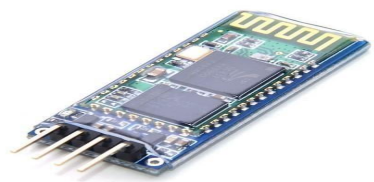


Oxygen Level Sensing Module:

This module will be used to measure if the respiratory systems are working or not. It measures the amount of oxygen present in the blood of a worker, and so will be useful in finding the worker is alive and healthy after an untoward accident takes place.

Location and Position Sensing Module:

Location sensor to find out the location of a particular worker is present using unique ID, Eg: Worker ID 8266 is in 1st floor. It also help to check in groups - The number of people working at a particular floor at a particular time. Position sensor will be useful to determine the number of people who are stuck in event of accident.



Heart Rate Detection Module:

This sensor is used to find out the rate of heartbeat of a particular user (Construction Worker). In a event of disaster this sensor is used to determine whether the worker is still alive or not to proceed with evacuation.

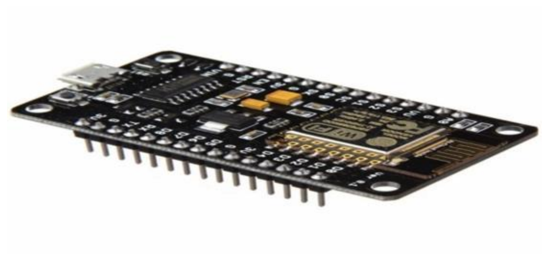
SPO2 sensor

The LED's present in this sensor, shines the light through the tissues, and the sensor present on the other side, finds out the amount of light which is transferred through the tissues to find out the amount of oxygen present in the blood stream.

Let us see in detail about the different components used in this kit,

ESP8266 board

This device is an economical Wi-Fi microchip, with a full TCP/IP stack and microcontroller ability. It allows microcontrollers to link to a Wi-Fi web and make simple TCP/IP interconnections making use of Hayes-style commands.



Location tracker (Bluetooth):

Location tracker receives the location based on the Bluetooth module which will be placed at each and every floor. Using this the location of each and every person can easily be located by the building’s supervisor.

Speaker:

A speaker is an electroacoustic transducer. This device changes an electrical audio signal into the corresponding sound.

ADX –average directional index (sensor-MPU6050):

The MPU6050 is a Micro Electro-Mechanical Systems (MEMS). It contains a 3-axis Accelerometer and a 3-axis Gyroscope inside it.This assists to calculate acceleration, velocity, orientation, displacement and many other motion allied parameter of a system or object.

LM35 (temperature):

LM35 is a temperature sensor that outputs an analog signal which is corresponding to the prompt temperature. The output voltage can easily be explained to obtain a temperature reading in Celsius. The lead of lm35 over thermistor is it does not need any external calibration.

Google firebase:

Firebase is the Google's mobile application development platform and helps you set up better, and expand your app.

Experimental result:

The output of this experiment is, that it is a system which can be worn easily by the construction workers in theirs hands while carrying out their job. It finds out if the person in question is standing straight or if he has fallen down, their heartbeat rate, and the status of their heartbeat, their location, the amount of oxygen in their blood, their body temperature and the status of their body’s temperature, and sends the result to the building supervisor’s system.

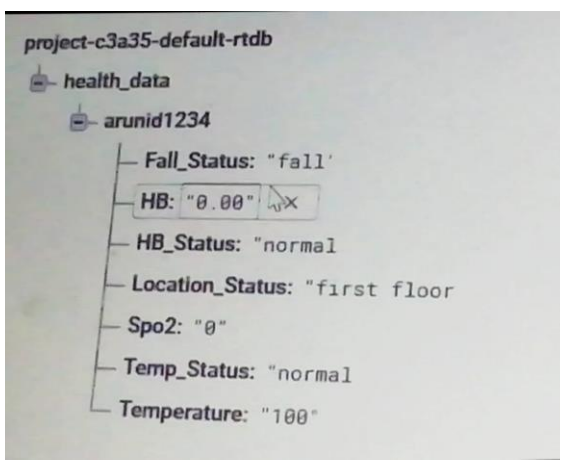
Output Image:

Hardware:

A kit enclosed in a plastic box and worn on the wrist of the construction worker is as shown in the image below.

Software:

The data output as shown for each person in the supervisor's system is shown in the image below.



Reference:

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7. A Smart Helmet for Air Quality and Hazardous Event Detection for the Mining Industry by Raghavendra Rao B, Karthik NS, NA Poojitha, Divya L, Nandini N.
8. Smart Helmet for Coal Miners using Zigbee Technology by Shirish Gaidhane , Mahendra Dhame & Prof. Rizwana Qureshi.
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10. Zigbee based intelligent helmet for coal miners by Pulishetty Prasad , Dr. K. Hemachandran , H.Raghupathi.
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sharing best practice in health, safety and wellbeing | British Safety Council (britsafe.org)

9. References:

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