A
Project Report
On
"Safety Management in a Factory"

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CERTIFICATE

This is to certify that the report entitled "**Safety Management in a Factory**" is a bonafide work carried out by **Miss. Nidhi Patel (18DCS076)** under the guidance and supervision of **Asst. Prof. Nilesh Dubey** and **Asst. Prof. Shivam Ribadiya** for the subject CS373 - **Internet of Things** (CSE) of 6th Semester of Bachelor of Technology in **DEPSTAR** at Faculty of Technology & Engineering – CHARUSAT, Gujarat.

To the best of my knowledge and belief, this work embodies the work of the candidate himself, has duly been completed, and fulfills the requirement of the ordinance relating to the B.Tech. Degree of the University and is up to the standard in respect of the content, presentation, and language for being referred to the examiner.

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ABSTRACT

The rise of ubiquitous systems are sustained by the development and progressive adoption of the Internet of Things (IoT) devices and their enabling technologies. IoT has been shown to have significant potential in high-risk Environment, Health, and Safety (EHS) industries. In these industries, human lives are at stake and IoT-based applications are primed to offer safe, reliable, and efficient solutions due to their ability to operate at a fine granular level and provide rich low-level information. We review existing published research on IoT-based applications in high-risk EHS industries with specific emphasis on the healthcare industry, food supply chain (FSC), mining and energy industries (oil & gas and nuclear), intelligent transportation (e.g., connected vehicles), and building & infrastructure management for emergency response operations. We also highlight IoT-related challenges and proposed solutions in high-risk EHS industries. We then conclude by presenting research challenges and expected trends for IoT in these industries.

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CHAPTER 01: PROJECT DEFINITION

1.1 PROJECT OVERVIEW

In an industrial and commercial world that keeps speeding up to match the soaring expectations of consumers, safety mustn't be left behind as operational efficiencies increase. Studies have recently linked the increasing speeds of fulfillment with working injuries—particularly in high-tech warehouses and distribution centers. Despite widespread efforts from senior management and facility managers, there is still room for improvement when it comes to industrial safety and injury prevention.

Advanced equipment and controls are now capable of collecting data, which is the first step toward network connectivity.

The industrial workplace is utilizing the Internet of Things (IoT) technology to improve safety. The Industrial Internet of Things (IIoT) applies various sets of hardware working together to enhance the manufacturing industrial process. This focus allows companies to increase energy efficiency, streamline communication, enhance productivity, and monitor events. Real-time and historical safety events can be communicated to safety managers through text and/or email alerts.

1.2 OBJECTIVES

Commercial Fire detection systems usually have an alarm signaling, with the help of a buzzer or Siren. We have designed an IoT-based Safety Management System using an ultrasonic sensor, PIR sensor, and a gas sensor which would not only signal the presence of fire in a particular premise but will also send related information through a Bluetooth module to an application. These changes will improve the productivity of a factory or plant, increasing their bottom line and making both management and employees happy. Also, Facility managers are increasingly looking for ways to proactively address potential safety issues, instead of merely reacting to accidents that might cause harm to employees. Advanced equipment and controls are now capable of collecting data, which is the first step toward network connectivity. In the industrial world, common wearable smart devices have been altered to provide metrics on additional health parameters. For example, smartwatches can monitor workers' exertion levels and body temperatures, then alert them (and their supervisors) when either becomes dangerously high. Here, our main objectives are :

- To interface following sensors such as Ultrasonic, Gas sensors with TinkerCAD Arduino and display readings on the console.
- To simulate an operation of obstacle detection and notifying it with a buzzer or LED using TinkerCAD Arduino.
- To sense the data from sensors and it can be read on an Android App.

CHAPTER 02: DESCRIPTION

Implementing IoT solutions can dramatically increase the efficiency of an operation. IoT can improve the efficiency of machinery by tracking performance and predicting failures ahead of time. This allows for preventive and routine maintenance that largely eliminates unplanned downtime. Thus, the machines have more uptime and man-hours aren't wasted trying to fix unexpected failures.

The most important function of industrial IoT is to make the workplace safer. As you'll see, many companies are implementing new technologies that are increasing worker safety by tracking their vitals and making machinery safer to work with. Minimizing workplace injury also helps optimize operational efficiency.

These changes will improve the productivity of a factory or plant, increasing their bottom line and making both management and employees happy. Luckily for us, there are many excellent examples where industrial IoT has already worked its magic.

Here, in our project, we have embedded three sensors together, namely, the ultrasonic sensor, the PIR sensor, and the gas sensor. It is a simulation-based project using the Proteus software. We have connected these sensors using the Arduino UNO and also used the Bluetooth module to send the data to be read from the Android Application. We have used MIT App Inventor to make the application.

CHAPTER 03: PROJECT REQUIREMENTS

SOFTWARE REQUIREMENTS

1. **PROTEUS 8 Professional Software**

Figure 1: Proteus 8 Professional

Proteus 8 Professional is software that can be used to draw schematics, PCB layout, code, and even simulate the schematic. You can simulate your work and be more efficient in completing the task at hand.

2. **Access to MIT App Inventor**

Figure 2: MIT App Inventor

MIT App Inventor is a web application integrated development environment originally provided by Google and now maintained by the Massachusetts Institute of Technology (MIT). It allows newcomers to computer programming to create application software(apps) for two operating systems (OS): Android, and iOS, which, as of 8 July 2019, is in final beta testing. It is free and open-source software released under dual licensing: a Creative Commons Attribution ShareAlike 3.0 Unported license, and an Apache License 2.0 for the source code.

3. **Arduino IDE**

Figure 3: Arduino IDE

Arduino IDE is open-source software that is mainly used for writing and compiling the code into the Arduino Module. It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

4. **An Android Device for the Application**

5. **Components required for the project**
    a. Arduino UNO
    Arduino 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 light-detecting sensors, motion sensors (Ultrasonic or IR), temperature sensors, etc. The output from this device can be received through other output devices such as LED, Buzzer, Serial monitor, etc.
    b. Passive Infrared Sensor(PIR Sensor)
    PIR sensors allow us to sense motion, almost used to detect whether a human has moved in or out of the sensor range. They are small, inexpensive,low-power, and easy to use.

    c. Ultrasonic Distance Sensor
    An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic waves.

    d. Gas Sensor
    The 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 measured in terms of Voltage.

    e. Bluetooth Module HC05
    HC-05 Bluetooth Module is an easy-to-use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with the controller or PC. HC-05 Bluetooth module provides switching mode between master and slave mode which means it is able to use neither receiving nor transmitting data.

    f. Potentiometer
    g. LEDs
    h. Logic State Source

CHAPTER 04: MAJOR FUNCTIONALITY

1. The ultrasonic sensor is connected to the Arduino board and the potentiometer is connected to the sensor. The input voltage in the potentiometer which when changed shows the difference in the measured distance between the object and the sensor.

   An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has traveled to and from the target).

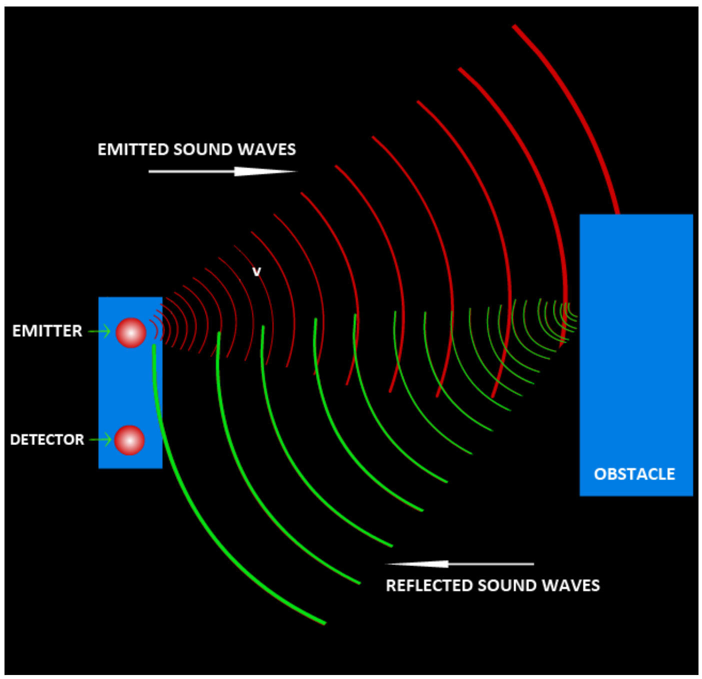

Figure 4: Ultrasonic Sensor Diagram

   To calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver. The formula for this calculation is D = ½ T x C (where D is the distance, T is the time, and C is the speed of sound ~ 343 meters/second). For example, if a scientist set up an ultrasonic sensor aimed at a box and it took 0.025 seconds for the sound to bounce back, the distance between the ultrasonic sensor and the box would be:

$$D = 0.5 \times 0.025 \times 343$$

   or about 4.2875 meters.

2. The gas sensor is also connected to the Arduino board and the logic source state is connected to the sensor. Whenever the state is changed to 1, the gas sensor activates and it is displayed that the gas is detected and whenever the state is changed to 0, it is displayed that the gas is not detected.

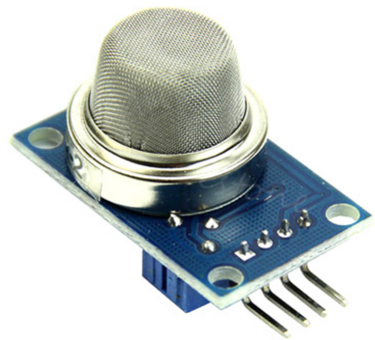

Figure 5: Gas Sensor

A gas sensor is a device that detects the presence or concentration of gases in the atmosphere. Based on the concentration of the gas the sensor produces a corresponding potential difference by changing the resistance of the material inside the sensor, which can be measured as output voltage. Based on this voltage value the type and concentration of the gas can be estimated.

The type of gas the sensor could detect depends on the sensing material present inside the sensor. Normally these sensors are available as modules with comparators as shown above. These comparators can be set for a particular threshold value of gas concentration. When the concentration of the gas exceeds this threshold the digital pin goes high. The analog pin can be used to measure the concentration of the gas.

3. The PIR sensor is also connected to the Arduino board and the logic source state is connected to the sensor. Whenever the logic state is changed to 1, This indicates that the object is being detected and so the blue LED turns on and when the logic state is changed to 0, this means that no object is detected.

   Generally, the PIR sensor can detect animal/human movement in a required range. PIR is made of a pyroelectric sensor, which can detect different levels of infrared radiation. The detector itself does not emit any energy but passively receives it.

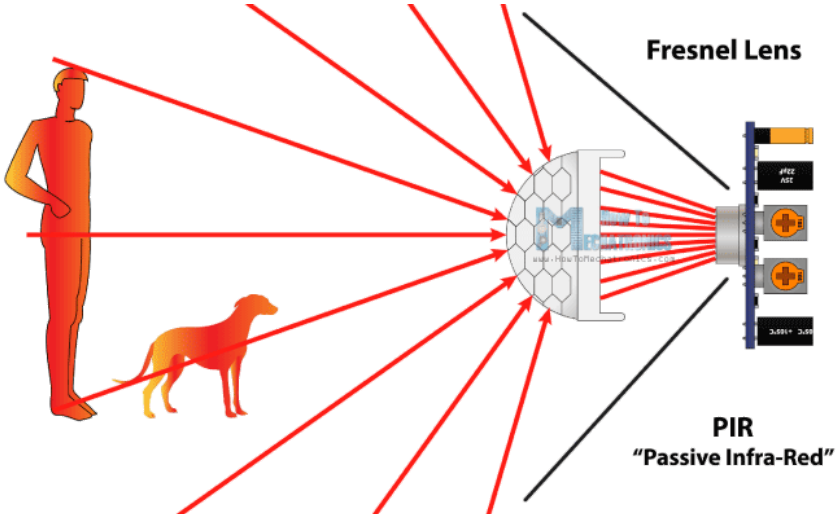

Figure 6: PIR Sensor

It detects infrared radiation from the environment. Once there is infrared radiation from the human body particle with temperature, focusing on the optical system causes the pyroelectric device to generate a sudden electrical signal.

Simply, when a human body or any animal passes by, then it intercepts the first slot of the PIR sensor. This causes a positive differential change between the two bisects. When a human body leaves the sensing area,the sensor generates a negative differential change between the two bisects.

4. Bluetooth Module HC-05
   HC-05 is a Bluetooth module which is designed for wireless communication. This module can be used in a master or slave configuration.
   Here we have connected the bluetooth module with the Arduino board so that we can read the sensor data from the Android Application whenever the phone is connected to the Bluetooth.

CHAPTER 05: CIRCUIT DIAGRAM AND CODE

CIRCUIT DIAGRAM

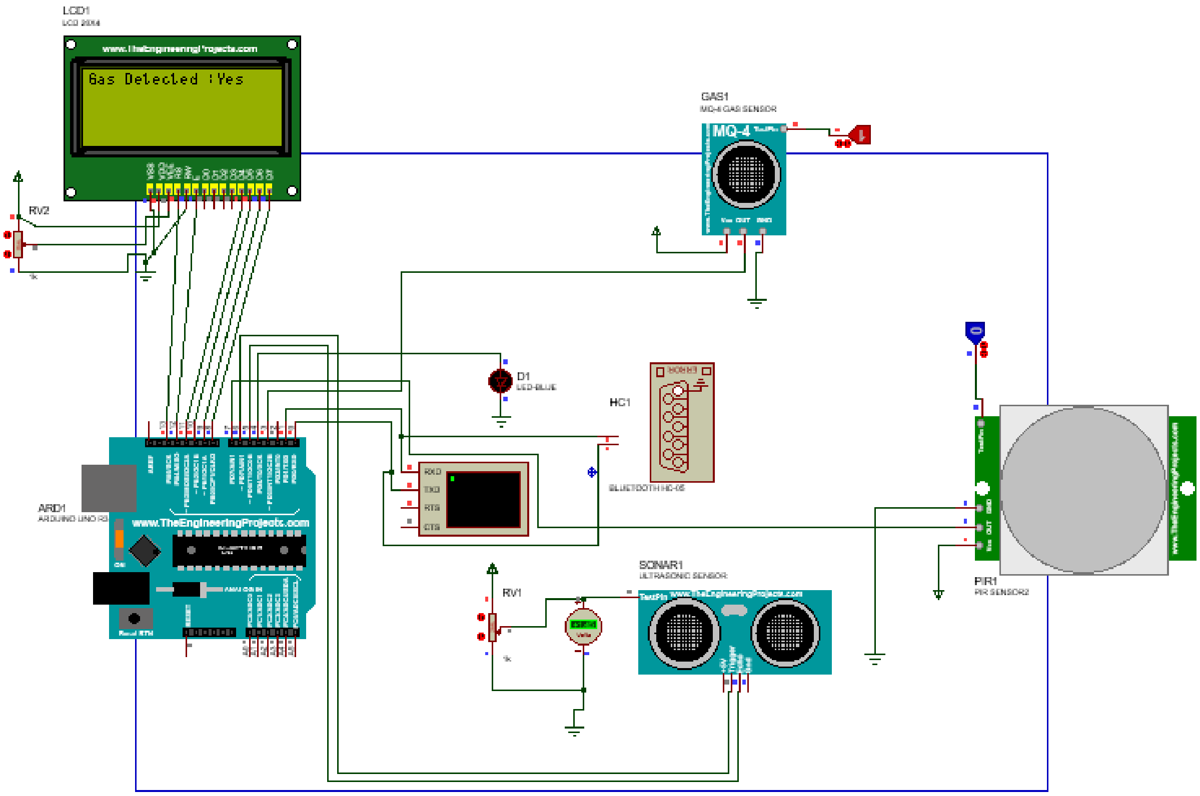

Figure 7: Circuit Diagram of the system

CODE

```
#include <LiquidCrystal.h>

const int pingPin = 6; // Trigger Pin of Ultrasonic Sensor
const int echoPin = 5; // Echo Pin of Ultrasonic Sensor
long duration;
int distanceCm;
int oldValue = 0 , newValue = 0;

//PIR sensor
#define pirPin 7
int LEDblue = 4;
int calibrationTime = 30;
long unsigned int lowIn;
long unsigned int pause = 5000;
boolean lockLow = true;
boolean takeLowTime;
int PIRValue = 0;

//Gas Sensor
// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(13, 12, 11, 10, 9, 8);
int Gas = 3;

void setup()
{
	Serial.begin(9600); // Starting Serial Terminal

	pinMode(pingPin, OUTPUT);
	pinMode(echoPin, INPUT);

	//PIR Sensor
	pinMode(pirPin, INPUT);
	pinMode(LEDblue, OUTPUT);

	//gas sensor
	// set up the LCD's number of columns and rows:
	lcd.begin(20, 4);
	// Print a message to the LCD.
	lcd.setCursor(0,0);
```

```
    lcd.print("Gas Detected :");
    pinMode(Gas , INPUT);
}

void loop()
{
    //Ultrasonic Sensor
    digitalWrite(pingPin, LOW);
    delayMicroseconds(2);
    digitalWrite(pingPin, HIGH);
    delayMicroseconds(10);
    digitalWrite(pingPin, LOW);
    duration = pulseIn(echoPin, HIGH);
    distanceCm = duration * 0.0340 / 2;
    newValue = distanceCm;
    if(newValue != oldValue)
    {
        //Serial.print("Distance: ");
        Serial.print(distanceCm);
        Serial.print("|");
        //Serial.println(" cm");
        oldValue = newValue;
    }
    else{
        Serial.print(distanceCm);
        Serial.print("|");
    }

    //Gas Sensor
    {
        if(digitalRead(Gas) == HIGH){
            lcd.setCursor(14,0);
            lcd.print("Yes");
            Serial.print("Yes ");
            Serial.print("|");
        }
        else{
            //if(digitalRead(Gas) == LOW){
            lcd.setCursor(14,0);
            lcd.print("No ");
```

```
                Serial.print("No ");
                Serial.print("|");
            }
        }

        //PIR Sensor
        //PIRSensor();
        {
            if(digitalRead(pirPin) == HIGH){
                PIRValue = 1;
                digitalWrite(LEDblue, HIGH);
                Serial.print("Motion-detected ");
                Serial.print("|");
            }
            else{
                PIRValue = 0;
                digitalWrite(LEDblue, LOW);
                Serial.print("Motion-ended ");
                Serial.print("|");
            }
        }

        delay(5000);
        system("cls");
}
```

CHAPTER 06: SCREENSHOTS OF THE PROJECT

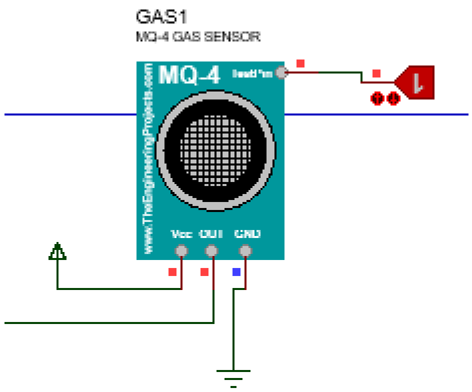

Figure 8: Gas Sensor

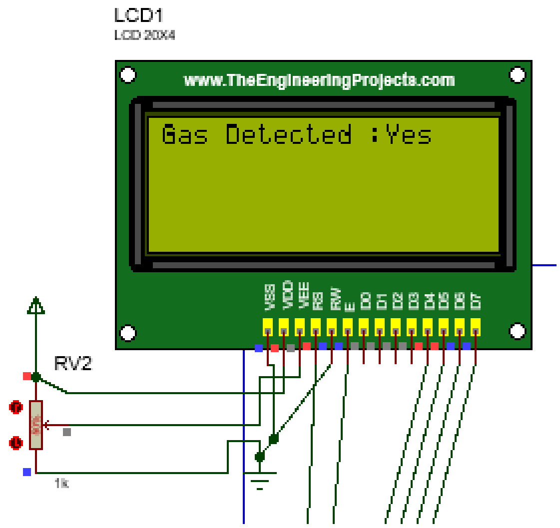

Figure 9: LCD displaying the data of gas sensor

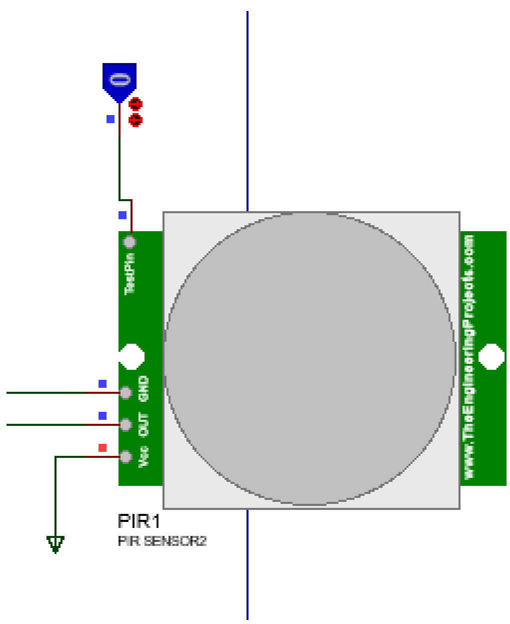

Figure 10: PIR Sensor

Figure 11: Virtual Terminal displaying the of PIR sensor

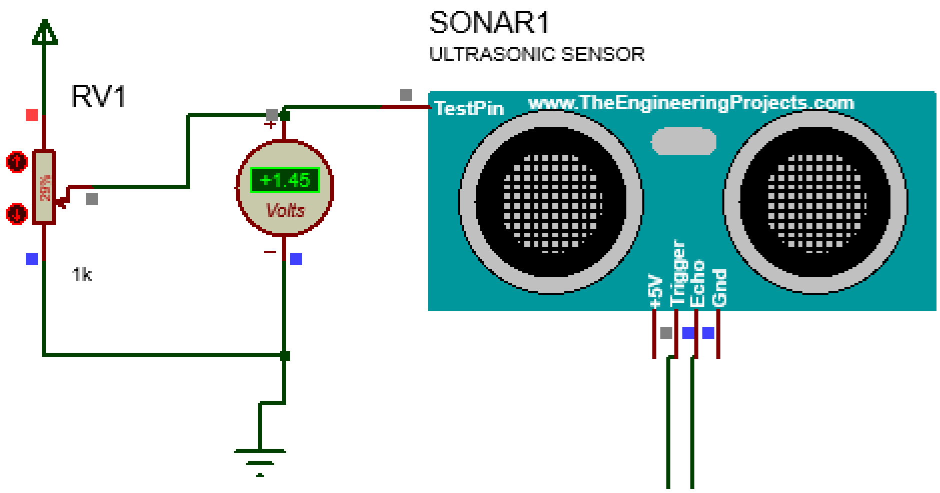

Figure 12: Ultrasonic Sensor connected to the potentiometer

Figure 13: Virtual Terminal displaying the distance measured my the Ultrasonic Sensor

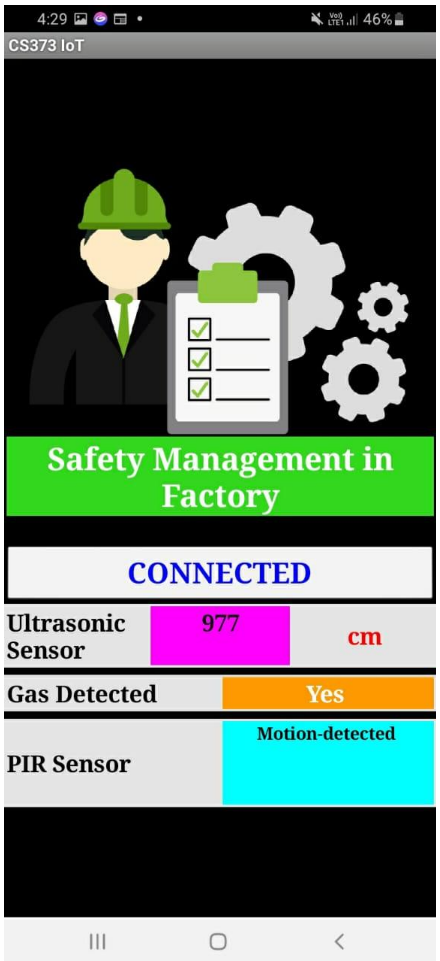

Figure 14: Android Application

CHAPTER 07: LIMITATIONS OF THE PROJECT

IIoT comes with some unique pitfalls due to its cyber-physical connection. In other words, when something goes wrong in the digital world, the consequences can play out in the real world.

For example, improper integrations–think faulty algorithms or miscalculations–could cause damage to your facility, end-product, or raw materials. Devices might overheat, explode, or malfunction in a way that damages products, equipment, or even injures your workers.

Also, adding more network-connected devices to your environment increases your attack surface. This creates more opportunities for cybercriminals to hack the system–whether as an act of sabotage, an attempt to collect ransom, or a political attack. Sometimes, hackers even gain access to machinery by chance.

However, keeping hackers out of your smart factory system isn’t the only thing you need to worry about. Connectivity, visibility, the skills gap, and ensuring that legacy equipment works with integrated devices all present unique challenges that could make or break an organization’s transformation efforts.

Firstly, the Android Application Would not be able to work without the bluetooth connection. Also the bluetooth connection ranges less so its not feasible to use the application if want to access it in a building. The bluetooth connection remains strong upto 10 metres.

Next is that the application is still under the development mode, if there is some emergency it cannot alert the user about it.

Also, this system will be used in a factory so there are a lot of chances that the sensors can wear-off or due to some malfunctionality the sensors get disrupted so it will be hard for a user to guess the active time period of the hardware.

CHAPTER 08: PROJECT OUTCOME

1. When we run the simulation, according to the logic states applied to the PIR sensor and the gas sensor, we will be able to get the output in the virtual terminal and also in the LCD.
2. When the logic state is 1 for the gas sensor, the LCD shows that the gas is detected and if it's 0 then it is vice versa.
3. When the logic state is 1 for the PIR sensor, the PIR sensor gets activated and so we can see in the virtual terminal that the object is being detected and also the blue LED turns on and when the logic state is 0, we can see that no object is being detected.
4. For the ultrasonic sensor, when the voltage input is changed using the potentiometer which is connected to the sensor, we can see that the distance measured is changed.
5. This all the data that is being read by the sensors according to different situations and conditions, this data is reflected in the Android Application on the phone.

CHAPTER 09: APPLICATIONS OF THE PROJECT

1. **Smart Helmets for Construction Workers**
    a. In this case of wearable technology helping improve worker conditions comes from a construction firm in Australia. The company is using smart helmets equipped with sensors to monitor worker safety. The helmets upload the collected data to the cloud where Microsoft Azure and Microsoft Power BI analyze it.
    b. Supervisors can use the data to determine if the worker has heatstroke, which is a serious risk in Australia's climate. The sensors monitor the temperature and heart rate of the wearer as well as the outside temperature and humidity. When the wearer is close to heatstroke, the helmet emits a warning sound that alerts the wearer. It can also wirelessly report the information to a supervisor.
    c. These cutting edge uses of IoT technology are just a couple of examples of the many ways that industrial IoT connects workers directly to their environments in a successful effort to make the workplace safer and more efficient.

2. **Make Mining Safer Using IoT**
    a. The group of workers most in need of safety advances are miners. While mining is vital to the world economy, the industry has had challenges with falling prices and attracting skilled labor. Industrial IoT has been helping solve those problems by doing what we've already seen: improving safety and efficiency.

3. **Faster Emergency Response**
    a. As critical events experienced by employees are instantly reported to the command center, pre-determined, automated workflows can be executed to accelerate evacuation and rescue activities. For example, when a worker falls from a height or suddenly passes out, alerts are triggered at the safety control center for timely dispatch of medical aids. Similarly, if atmospheric gas levels surpass the tolerated threshold or an imminent explosion is detected, employees are immediately notified and evacuated out of the endangered areas.

4. **Enhancing workers' health, wellness, and productivity**
    a. Improved visibility into work environments also help avoid prolonged exposure to harsh conditions like CO2, radiation, noises, heat or humidity. Sensor data enables managers to watch out for any signs of fatigue, dehydration or exhaustion encountered by their workers, thus encouraging them to take a recovery break, as needed. Minimizing overexertion not only improves overall productivity, but also reduces the risk of injuries, accidents and chronic diseases.

5. **Applications of Ultrasonic and PIR Sensors**
    a. Both PIR and ultrasonic detection can be used in standalone systems and 'connected' (IoT) systems, principally to detect the presence of humans – but there are other applications as well.

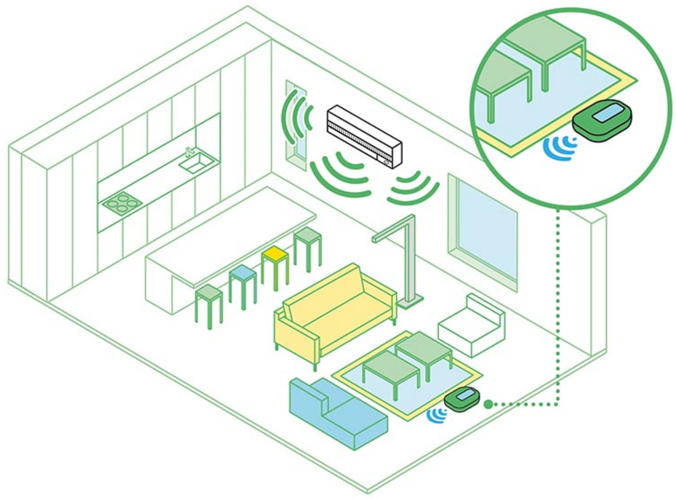

Figure 15: Ultrasonic sensors can be used for room-level sensing and individual robotic appliances

    b. PIR sensors are very commonly used in security or intrusion detection systems in both domestic and commercial applications. As they are placed away from the potential point of entry (door or window) they will detect any intruder before they are able to reach the sensor and tamper with it.

6. **Applications of Gas Sensor**
    a. Used in industries to monitor the concentration of the toxic gases.
    b. Used in households to detect an emergency incident.
    c. Used at oil rig locations to monitor the concentration of the gases that are released.
    d. Used at hotels to avoid customers from smoking.
    e. Used in air quality check at offices.
    f. Used in air conditioners to monitor the CO_2 levels.
    g. Used in detecting fire.
    h. Used to check concentration of gases in mines.
    i. Breath analyzer.

7. **Specific areas for implementation**
    a. Vehicle restraints: An employee may attempt to operate the leveler without engaging the restraint. The event will be logged, and the safety contact can receive an alert.
    b. Dock door barrier: Identify a potentially unsafe event when the dock door is left open with no trailer present and the barrier is not engaged.
    c. Motion sensors and light communication: When there is activity in the trailer, a blue light emits and prevents the vehicle restraint from erroneously unlocking the trailer when activity inside is detected.

CHAPTER 10: FUTURE ENHANCEMENTS

1. We will be developing a full Android Application for the system, which will be able to alert the user. For e.g., let's assume that there is an ultrasonic sensor and a PIR sensor which is connected at the front gate of the door of a private room and the gas sensor is connected inside the room where there is manufacturing process going on. So if any time there is an object or an animal or any person trying to come in that area where the private room is there then the PIR sensor will sense that object and the buzzer connected to it will start ringing and also the ultrasonic sensor will count the distance how much far is it and will alert the safety manager about this using this app.
2. Next is to connect this system using the WiFi module so this system can be used over a big range.
3. A safety revolution is coming by the way of interconnected devices. Whether it's at the loading dock or inside the plant, facilities that have already invested in IIoT are seeing the safety benefits. According to a PwC survey published in Industry Week, 93 percent of manufacturers believe IoT benefits exceed the survey revealed that approximately 70 percent of industrial manufacturers plan to increase their investment into IoT within the next two years. Companies that aren't using IoT to improve the safety in their manufacturing plants in the very near future are at risk of falling behind the competition.

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