Iot Based Gas Leakage Detector

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ABSTRACT

Gas pipes fulfill vital roles for cities, industries and thusin growing economies. In today's world, major cities like Delhi, Mumbai etc. are getting LPG supply by LPG Pipeline. So, gas leakages lead to threat because they can also lead to fire accidents and create hazardous situations. One of the preventive methods to put an end to accidents associated with gas leaks is to install a gas leak detection kit in vulnerable places, where the chances of gas leakage is high by creating an innovative robot that can sense the gas leakage from the outer surface of pipeline and if it detects gas leakage it will send alert messages to the user with the help of GSM module 800c and MQ-9 gas sensor. The robot or car has wheels, and with the help of a remote controller it can be controlled by the user. The robot has a gas detection system and a GSM module installed on it. The robot goes on the surface of the pipeline and checks the chances of leakage in the pipeline if any gas leakage is sensed by MQ-9 sensor it will send an alert SMS via the help of the GSM module to the respective mobile phone number.

Keywords: IoT, GSM module, MQ-9 gas sensor, robot car, pipeline, leakage

INTRODUCTION

1.1. Internet of Things

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The Internet of Things is a simple concept; it means taking all the physical places and things in the world and connecting them to the internet.

On the Internet of Things, all the things that are being connected to the internet can be put into three categories: things that collect information and then send it, things that receive information and then act on it, things that do both, and all three of these have enormous benefits that compound on each other. Key benefits of IoT technology are Technical Optimization, Improved Data Collection, and Reduced Waste.
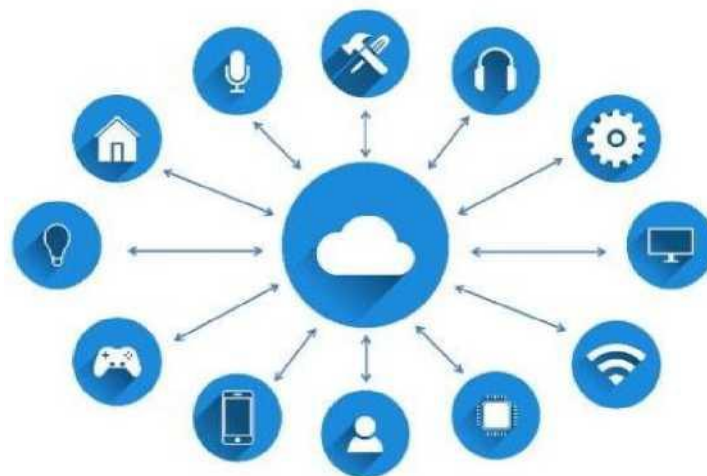

Figure 1.1 Internets of Things

A whole industry has sprung up with a focus on filling our homes, businesses, and offices with IoT devices. These smart objects can automatically transmit data to and from the Internet. All these "invisible computing devices" and the technology associated with them are collectively referred to as the Internet of Things.

1.2. Importance of Internet of Things Technology

IoT is so important because the use of internet-connected devices has become main stream, and companies in diverse industries are adopting this technology so as to be more efficient, productive, and competitive.

IoT allows companies to reduce costs, increase safety, and improve quality from end-to-end, which translates to a win-win for everybody, and also automate processes and save money on labor. It also reduces waste and improves service delivery, making it less expensive to manufacture and deliver goods and providing transparency to customer transactions.

1.3. Background and Context

Gas leak detection methods became a concern after the effects of harmful gases on human health were discovered. Before modern electronic sensors, early detection methods relied on less precise detectors. Through the 19th and early 20th centuries, coal miners would bring canaries down to the tunnels with them as an early detection system against life-threatening gases such as carbon dioxide, carbon monoxide and methane.

According to ABS-CBN news 2017 that from January to June last 2017, the BFP has recorded a total of 2,522 fire incidents. It was traced that LPG is one of the major causes of fire during that year where half of the total which is 1,253 beside from the electrical causes. Arduino has more lifetime because of a reason that thousands of projects from everyday bodies to complicated scientific mechanism. Worldwide societies of scholars, performers, programmers, and specialists have assembled around this open-source program.

Their knowledge about the said matter contributions a lot to help the society in this subject area. The project entitled "Gas Leakage Detector Robot using Arduino with SMS Alert and Sound Alarm" will be a great help in terms of preventing any danger caused by gas leakage. The purpose of this project is to detect the presence of gas leakage as a part of a safety system. Descriptively, we use a gas sensor to monitor the gas if the gas leak reaches beyond the normal level. This proposed project will trigger the sound alarm. In addition, the authorized person will be informed about the leakage via SMS alert. The people can be saved from a potential explosion caused by gas leakage.

The canary, normally a very songful bird, would stop singing and eventually die if not removed from these gases, signaling the miners to exit the mine quickly. The first gas detector in the industrial age was the *flame safety lamp* (or Davy Lamp) was invented by Sir Humphrey Davy (of England) in 1815 to detect the presence of methane (firedamp) in underground coal mines. The flame safety lamp consisted of an oil flame adjusted to specific height in fresh air.

To prevent ignition with these lamps the flame was contained within a glass sleeve with a mesh flame arrestor. The flames height varied depending on the presence of methane (higher) or the lack of oxygen (lower). To this day, in certain parts of the world flame safety lamps are still in service. The modern era of gas detection started in 1926–1927 with the development of the catalytic combustion sensor by Dr. Oliver Johnson. Dr Johnson was an employee of Standard Oil Company in California (now Chevron), he began research and development on a method to detect combustible mixtures in air to help prevent explosions in fuel storage tanks.

A demonstration model was developed in 1926 and denoted as the Model A. The first practical "electric vapor indicator" meter begun production in 1927 with the release of the Model B. The world's first gas detection company, Johnson- Williams Instruments (or J-W Instruments) was formed in 1928 in Palo Alto, CA by Dr Oliver Johnson, and Phil Williams. J-W Instruments is recognized as the first electronics company in Silicon Valley.

Over the next 40 years J-W Instruments pioneered many "firsts" in the modern age of gas detection, including making instruments smaller and more portable, development of a portable oxygen detector as well as the first combination instrument that could detect both combustible gases/vapours as well as oxygen. Before the development of electronic household carbon monoxide detectors in the 1980s and 1990s, carbon monoxide presence was detected with a chemically infused paper that turned brown when exposed to the gas. Since then, many electronic technologies and devices have been developed to detect, monitor, and alert the leak of a wide array of gases.

As the cost and performance of electronic gas sensors improved, they have been incorporated into a wider range of systems. Their use in automobiles was initially for engine emissions control, but now gas sensors may also be used to ensure passenger comfort and safety. Carbon dioxide sensors are being installed into buildings as part of demand controlled ventilating systems.

Sophisticated gas sensor systems are being researched for use in medical diagnostic, monitoring, and treatment systems, well beyond their initial use in operating rooms. Gas monitors and alarms for carbon monoxide and other harmful gases are increasingly available for office and domestic use and are becoming legally required in some jurisdictions.

Originally, detectors were produced to detect a single gas. Modern units may detect several toxic or combustible gases,

or even a combination. Newer gas analyzers can break up the component signals from a complex aroma to identify several gases simultaneously.

Metal oxide semiconductor sensors (MOS sensors) were introduced in the 1990s. MOS sensors have since become important environmental gas detectors. An LPG gas sensor detector is used to detect the presence of liquid petroleum gas leakage that may be source of risk and help to avoid information sent to fire station being delayed if any accident happened. It will detect the presence of gasses using MQ2 sensor, if the sensor detects the level of gasses is exceeding the normal level it will send information through the phone apps through Internet of Thing (IOT).

Gas sensor MQ9 is a sensor that detects gases, specifically hydrogen (H2), Liquid Petroleum Gas (LPG), Methane (CH4), Carbon Monoxide (CO), Alcohol, Propane, and Smoke at the atmosphere.

1.4. Problem Statement

Liquid Petroleum Gas (LPG) is a highly flammable chemical that consists of mixture of propane and butane. LPG is used for cooking at home, restaurant, and certain use for industry. They have certain weaknesses that make the gas leakage occur. The leakage of gases only can be detected by human nearby and if there are no human nearby, it cannot be detected. But sometimes it cannot be detected by human that has a low sense of smell. Thus, this system will help to detect the presence of gas leakage.

Furthermore, gas leakage can cause fire that will lead to serious injury or death, and it also can destroy human properties. This system was developed by using IoT to give real-time response to the user and the nearest fire station. Natural gases such as Liquefied Petroleum Gas (LPG) are widely used in the whole world. LPG is used for cooking in home or hotel. It is also used in certain gas-based industry.

Even though human still have certain weakness. Human cannot detect the presence of natural gases as fast as the sensor do. Thus, the use of gas sensing system is hugely needed to give real-time monitoring of the gas system. In certain cases, gas leakage can cause fire that will destroy human property. The large scale of fire also could contribute to serious injury or death. This is due to the fire station got delay information about the fire occurred.

The current products that are in the market are function as gas detector. It will only detect a gas and trigger an alarm. The main problem is that even the alarm is triggered but if the user is not at home or premise, the user will not get to know the leakage of gas occur. Therefore, this project shall be able to resolve the problem stated. This is because this project "SMS NOTIFIER GAS LEAKAGE DETECTOR" can sense the presence of gas. Besides that, it gives information more efficient as it is also capable to send out an SMS to the owner.

Fig.1.2 Gas Leakage in Pipes

1.5. Non-autonomous robots

Guided mobile robots or non-autonomous robots require some sort of guidance system or instruction to make a movement that allows them to travel pre-defined navigation map such as magnetic tape, bar codes, wire or sensors installed on the environment's floor that creating on inflexible environment. These are the following types:

- Autonomous Guided Vehicle(AGV)
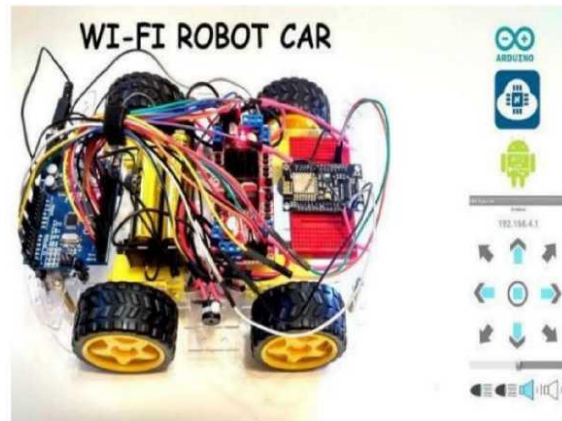- Rail Guided Vehicle(RGV)
- Guided Fork-lifts

Figure 1.3 Wi-Fi Robot Cars

1.6. General Objective
To layout and acquire a project on "Gas Leakage Detector using Arduino with SMS Alert and Sound Alarm".

1.7. Specific Objective
To layout and acquire project that will perceive gas outflow like Methane leak, Butane leak, and LPG leak, Methane outflow or any such petroleum centered on gaseous substance that can be discovered using MQ9 device to layout and set up an SMS centered alert method and send SMS alert missives to restrict mobile number entered inside the Arduino program to layout and acquire a project that will fabricate a sound alarm during gas outflow and rest the alarm once gas outflow is regulated show status in an LCD using a 16×2 LCD component.

1.8. Significance of the study
A gas detector is a device that detects the presence of gases in an area, often as part of a safety system. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals. Gas detectors can be used to detect combustible, flammable and toxic gases, and oxygen depletion. This type of device is used widely in industry and can be found in locations, such as on oil rigs, to monitor manufacturing processes and emerging technologies such as photovoltaic. They may be used in firefighting.

Gas leak detection is the process of identifying potentially hazardous gas leaks by sensors. Additionally, a visual identification can be done using a thermal camera. These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected.

Common sensors include combustible gas sensors, photo ionization detectors, infrared point sensors, ultrasonic sensors, electrochemical gas sensors, and metal-oxide-semiconductor sensors (MOS sensors). More recently, infrared imaging sensors have come into use. All of these sensors are used for a wide range of applications and can be found in industrial plants, refineries, pharmaceutical manufacturing, fumigation facilities, paper pulp mills, aircraft and shipbuilding facilities, hazmat operations, waste-water treatment facilities, vehicles, indoor air quality testing and homes.

One of the preventive measures to avoid the danger associated with gas leakage is to install a gas leakage detector at vulnerable locations. Gas leakage problem is highly become current issues that be the main causes of fire burning. This project is produced to detect any leakage of cooking gas and it will alert the user about leakage. User will get the alert in SMS. By using this project, it will reduce the accident of fire and explosion. It also helps the early detection of gas before the concentration of gas reaches the dangerous le

LITERATURE REVIEW

1. Ch.Rajendra Prasad*et-al.* [1] The presence of hazardous gas leakage in a domestic and work place, also stored gases in container which exhibits ideal characteristic for use. For that sake, an alarm unit is used to vibrate an alarm which is buzzer. Buzzer gives an audible sign of the presence of gas volume. The sensors are widely used to detect essence of propane, isobutane, Liquified petroleum gas and even smoke. The sensor has an advantage to combine a sensitivity response time. If the LPG sensor senses gas leak from work place or home, sensor output goes to active low (logic- 0) condition. Arduino Uno is used in the project; low signals are overlooked by the Arduino and gas leakage is been noticed by the Arduino.

2. Taimur Ahad, NilaSultene*et-al.* [2] A gas leakage detector is a device for detecting gases in an area that is often used in a security system. This type of equipment is used to detect gas leakage or another emission. A gas warning

device can alert operators in the vicinity of a possible gas leak and enable them to escape. The device is important because many gases can be harmful to organic life, such as humans or animals. This can be used to detect flammable, flammable, and toxic gases, as well as a lack of oxygen. Identifying potentially dangerous gas leaks through sensors.

3. Juhi chaudhary, Anuragmishra*et-al.* [3] LPG is a significant and effective fuel, for the most part utilized as a part of private spots for cooking. LPG for the most part filled in cylinder which is solid and can't be harmed effortlessly. In any case, breaks may happen from gas cylinder, controller and gas pipe tube when these are definitely not in a decent condition and may cause a mishap. Mischance's may prompt medical problems like suffocation and potentially cause an impact on the start of any fire or electric supply. One of the important preventive methods to stop mischance related with the gas spillage is to introduce gas leakage detector at vulnerable places.

4. Humberto Xavier-Program *et-al.* [4]., This paper presents a system to improve the security of houses and properties that uses LPG gas. Given its flammability, an alarm system is strongly advised. To solve this issue, we house owner in a matter of seconds, at the beginning of a gas leak. Our system deals with limitations on Internet connectivity, using a clever solution to this problem.

5. Mohammad Manirujjaman Khan*et-al.* [5]., Gas leakage is a major problem in the industrial sector, residential premises, etc. Nowadays, home security has become a major issue because of increasing gas leakage. Gas leakage is a source of great anxiety with ateliers, residential areas and vehicles like Compressed Natural Gas (CNG), buses, and cars which are run on gas power. One of the preventive methods to stop accidents associated with the gas leakage is to install a gas leakage detection kit at vulnerable places. The aim of this paper is to propose and discuss a design of a gas leakage detection system that can automatically detect, alert and control gas leakage. This proposed system also includes an alerting system for the users. The system is based on a sensor that easily detects a gas leakage.

6. R.Rajesh Sharma *et-al.* [6]., It's well- known that industrial safety is now a top concern. Nowadays, accidents caused by flammable gases occur frequently in our everyday lives. Gas cylinders, which are used for household purposes, wide range of businesses, and vehicles are often reported to be on the verge of exploding. Explosions have left a large number of individuals seriously wounded or could also be lethal in certain cases.

7. This project's goal is to use a HOG features for SVM classifier which is used to identify pipeline gas leaks and keep tabs on them. In addition, the system utilizes an image processing technique to identify pipeline fractures. Early detection and identification of pipeline flaws is a predominant aspect of this study. According to the suggested design, the robot captures the image down the pipe, looking for any signs of gas leakage by the Eddy Current method. This type of recognition has proved superior to other traditional methods. The methods with efficiency parameters and the results were compared and are tabulated in the results section. In the future, the data in the course of detection could be sent through GSM to a mobile application.

MATERIALS AND METHODOLOGY

3.1.1 Arduino Uno
Arduino Uno is one of the types of the Arduino Boards. The Arduino consist microcontroller that is used to perform the several operations and handling the other IoT devices like sensors and various modules. This microcontroller is a single chip microcomputer which consists of at least a microprocessor, program memory, data memory and input/output devices. It is characterized by its integration, a lower electric consumption.
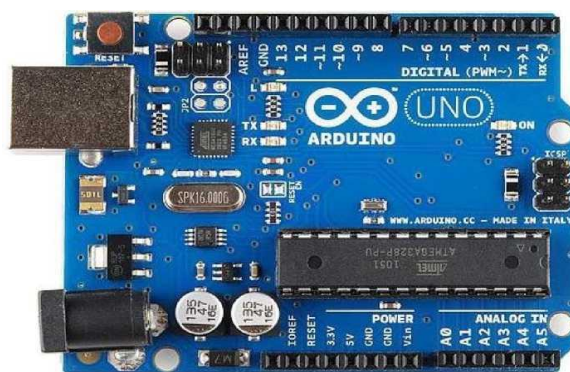

Figure 3.1.Arduino Uno Board

Table 3.1 Specifications of Arduino Uno

S.No.	Parameter	Value
1.	Operating Voltage	5 volts
2.	Input voltage	7 to 20 volts
3.	Digital input pins	14
4.	Analog input pins	6
5.	DC current per input pin	20mA
6.	DC current for 3.3V pin	50mA
7.	Flash memory	32KB of which 0.5KB used by bootloader
8.	SRAM	2KB
9.	EEPROM	1KB
10.	Clock speed	16MHz
11.	Length	68.6mm
12.	Width	53.4mm
13.	Weight	25g

General Pin Functions

- **LED**: There is a built-in LED driven by digital pin 13. When the pin is high value, the LED is on, when the pin is low, it's off.
- **VIN**: The input voltage to the Arduino board when it's using an external power Source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin or, if supplying voltage via the power jack, access it through this pin.
- **5V**: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 20V), the USB Connector (5V), or the VIN pin of the board (7-20V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the board.
- **3V3:** A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND:** Ground pins.
- **Reset:** Typically used to add a reset button to shields which block the one on the board
- **USB to PC:** It is used to communicate Arduino via Universal Serial Bus to PC programming/sending data to Arduino serially.
- **5V to 12V DC Input:** For external supply, the voltage range of 7V to 12V DC is recommended. The 9V battery can be used to power your Arduino Uno board.
- **SDA:** Serial Data, it is the bidirectional data line that is used by I2C.

3.1.2   MQ-9 Gas Sensor

The MQ-9 sensor is used to detect the gases from the leakage pipeline. The MQ-9 gas sensor is useful for sensing the gas in home as well as in the industrial use. The MQ-9 sensor can be able to detect LPG, CH4, CO from the air. MQ-9 sensor is highly responsive and sensitive sensor. The MQ-9 sensor consists A0 pin, VCC pin and GND pin. There is not an accurate or exact measurement for sensing the LPG gas from the sensor. Even lpg gas presence is 1% in air; it can sense and concentrate gas from 200ppm to 10000ppm. There is not an exact formula for sensing the gas but minimum 10% lpg gas is common measurement for sensing the lpg leakage. The sensor can be adjusted via using potentiometer or backside sensing adjustment setting.

Figure 3.2. Mq-9 Gas Sensor

Table 3.2 Specifications of MQ-9 Gas Sensor

S. No.	Parameter	Value
1	Operating Voltage	5V
2	Current Consumption	150
3	Load Resistance	20KΩ
4	Heater Resistance	33Ω±5%
75	Heating Consumption	Less than 340mW
6	Preheat Time	Over 48 hours

3.2. Methodology

In this, semiconductor sensors are used to detect the gases. An MQ9 semiconductor sensor is used. Sensitive material of the MQ9 gas sensor is SnO_2, which has lower conductivity in clean air. When the target combustible gas exists, the sensor conductivity increases along with the rising gas concentration. The MQ9 gas sensor has a high sensitivity to Propane, Butane, Hydrogen, alcohol vapour and LPG, and response to Natural gas. The sensor could be used to detect different combustible gasses, especially Methane; it is of low cost and is suitable for different applications. The MQ9 can detect gas concentrations anywhere from 200 to 10,000 ppm. The sensor's output is an analog resistance. Figure 1 shows the block diagram of the gas leakage detection and alert system.
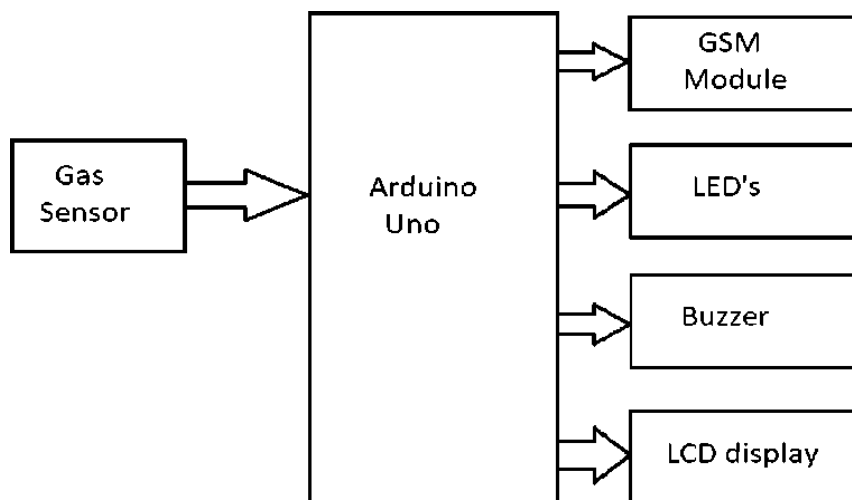

Figure 3.11 Block Diagram of Gas Leakage Detection and Alert System.

This system is based on the Arduino UNO R3 and MQ9 gas sensor. When the sensor detects gas in the atmosphere, it will give digital output 1 and if gas in not detected the sensor will give digital output 0. Arduino will receive the sensor output as digital input. If the sensor output is high, then the buzzer will start tuning along with the LCD that will show that "Gas detected: Yes". If the sensor output is low then buzzer will not be tuning, and the LCD will show that "Gas detected: No". The buzzer most commonly consists of a number of switches or sensors connected to control unit that determines which button was pushed or whether a preset time has lapsed, and usually illuminates a light on the appreciate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. For the design of a sensor-based gas leakage detector and alarm system the following hardware components are required. The gas detector system is very cheap and it will cost only. The device is portable, light weight, user friendly and efficient with multi-functional features.

4. EXPERIMENTAL SETUP

4.1. Introduction

The previous chapter presented the theoretical study relative to the method (hardware and software designs) used in designing of the gas leakage detection system with SMS alert and buzzer sound. This chapter presents relevant results obtained from the theoretical study relative the method used in implementing gas leakage detection system with SMS alert and buzzer sound.
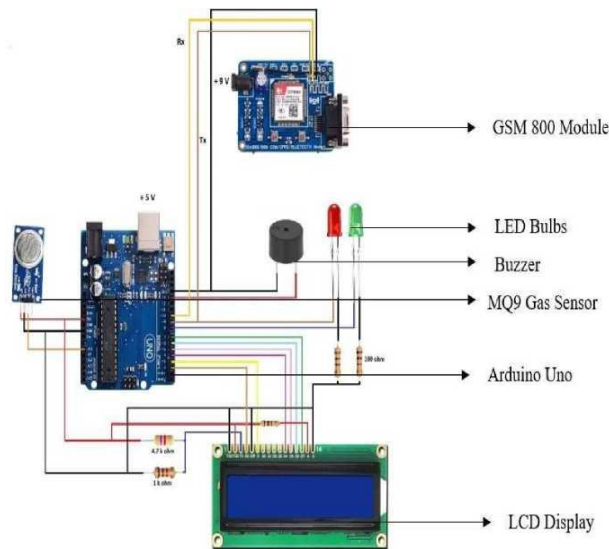
4.2. Arduino Circuit Diagram

Figure 4.1 Arduino Circuit Diagram

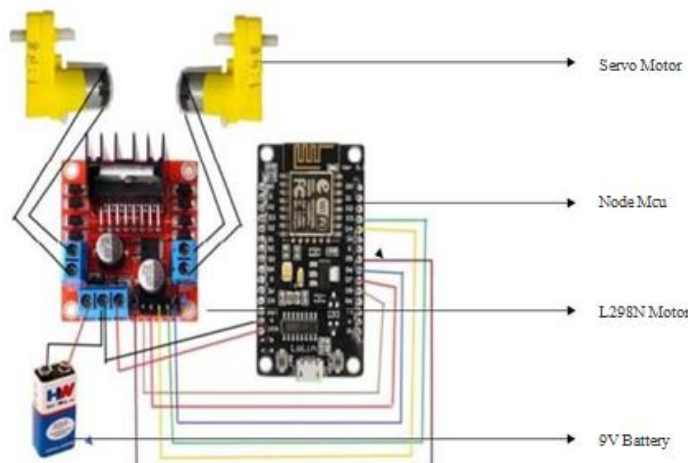### 4.3. Motor Circuit Diagram

Figure 4.2 Motor Circuit Diagram

4.4. Working Principle

Home Gateway, GSM module, buzzer, LED and robot are the main components of the system. The GSM module will send an SMS to a mobile phone number, and the home gateway will manage the signal and interpret the data received from the GSM. The sensor will detect gas leakage once the system is launched, if there is no gas leakage, it will show nothing that means normal condition. If the gas is leaked otherwise, the following scenario will happen. First of all, a signal from the microcontroller will go to the sensor and alert gas leakage message over the mobile then the buzzer will be beeped and the Red LED will be blinked until the gas leakage closed from the source.
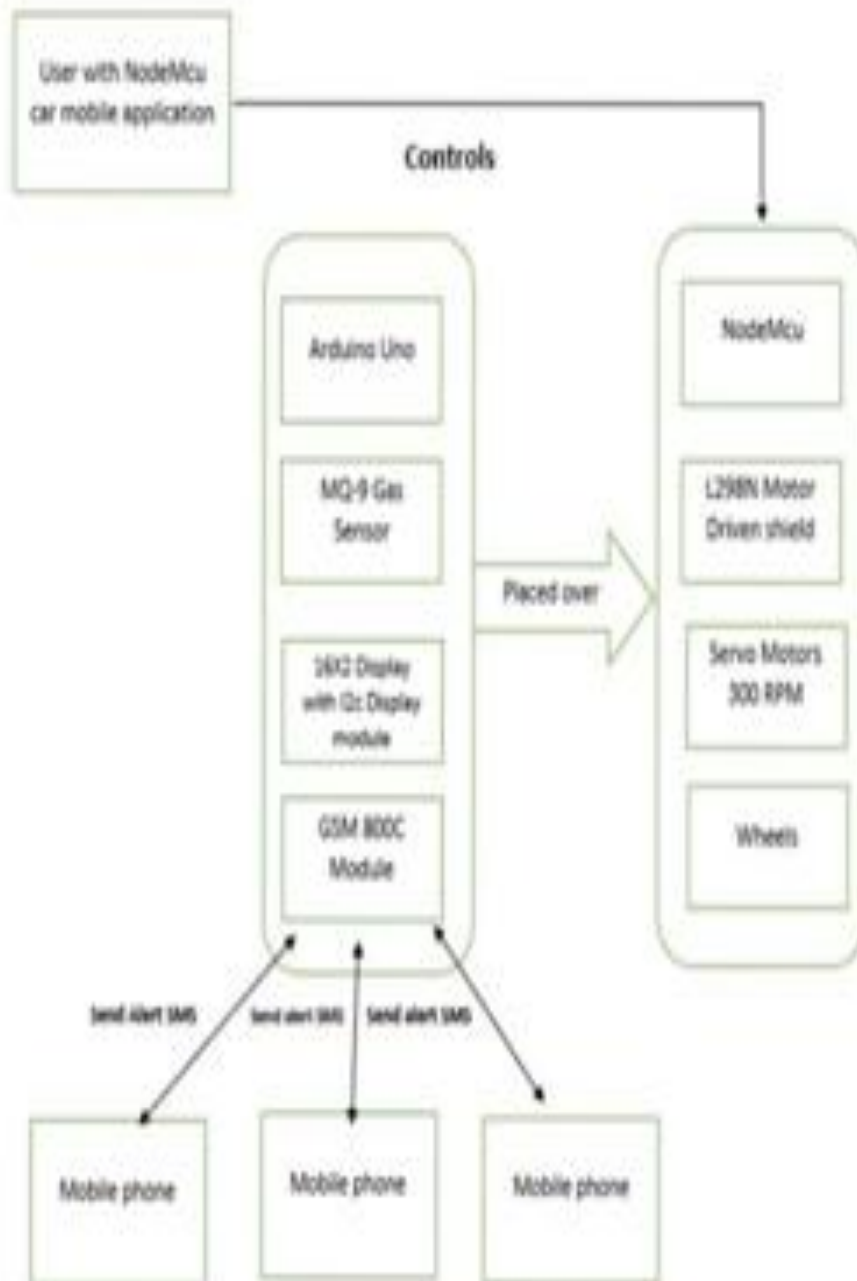
4.5. BLOCK DIAGRAM

Figure 4.3Block Diagram of Gas Leakage Detection System
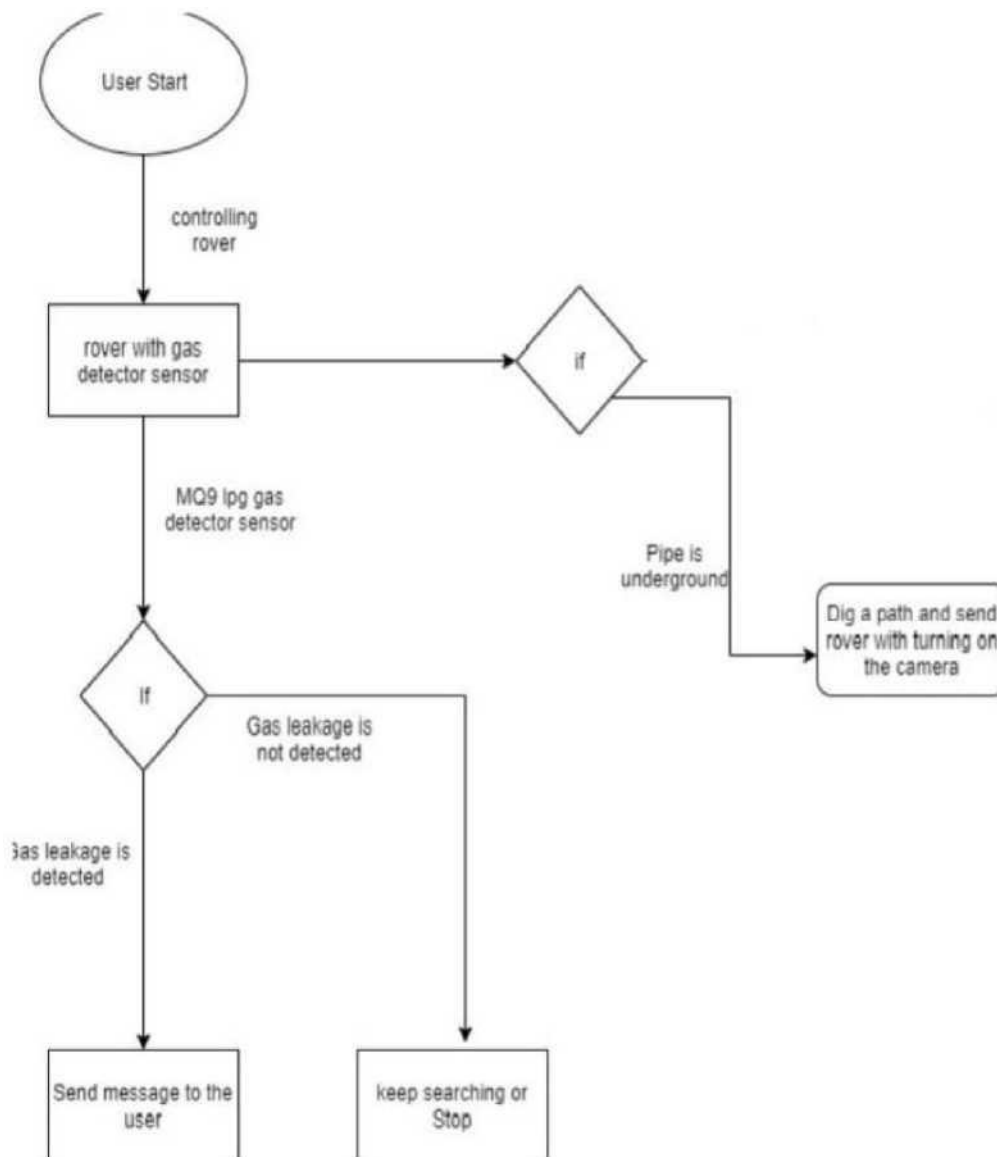
4.6. FLOW CHART

Figure 4.4 Flowchart of Gas Leakage Detection System

SOFTWARE IMPLEMENTATION

5.1. Introduction to Arduino IDE

- Arduino IDE is open-source software that is mainly used for writing and compiling the code into the Arduino Module.
- It is 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.
- It is easily available for operating systems like MAC, Windows and Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role for debugging, editing and compiling the code in the environment.
- A range of Arduino modules are available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more.
- Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code.
- The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board.
- The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module.
- This environment supports both C and C++ language

5.2. Process to install Arduino software (IDE)

- Download the Arduino Software (IDE)
- Proceed with board specific instructions
- Download the Arduino Software (IDE)
- Get the latest version from the download page. You can choose between the Installer (.exe) and the Zip packages. We suggest you use the first one that installs directly everything you need to use the Arduino Software (IDE), including the drivers. With the Zip package you need to install the drivers manually. The Zip file is also useful if you want to create a portable installation

@ Arduinc Setup InTtallctirn Option:

check the components you want to install and uncheck the components you don't want to install, Clide Next to continue,

Select components tnInstall;   121 Install Arduino software
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- When the download finishes, proceed with the installation and please allow the driver installation process when you get a warning from the operating system.
- Choose the components to install
- Choose the installation directory
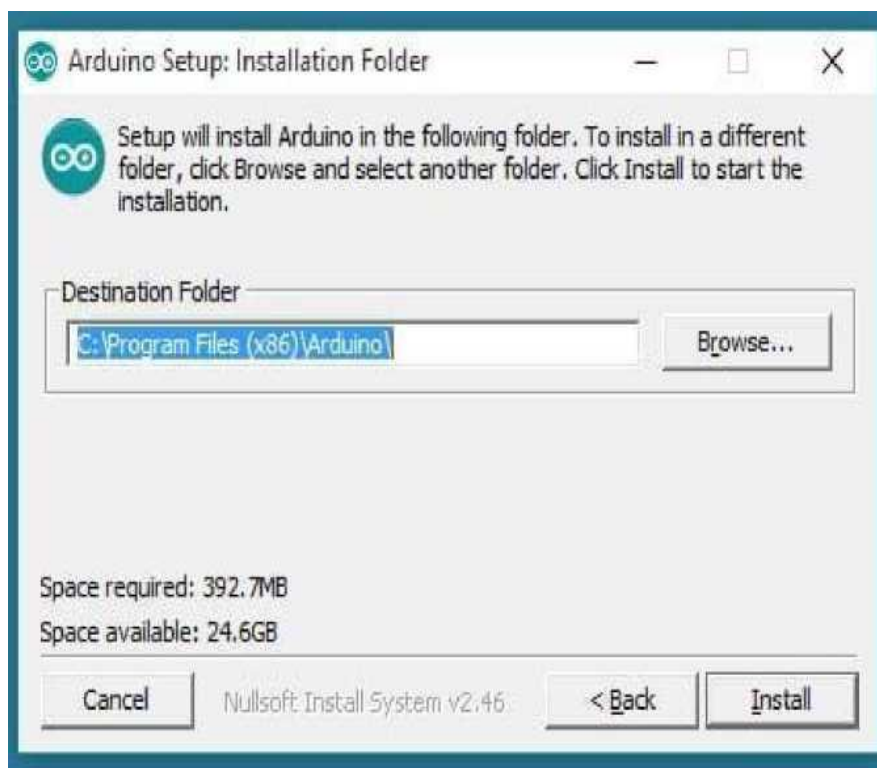
The process will extract and install all the required files to execute properly the Arduino Software (IDE).
- Proceed with board specific instructions
- When the Arduino Software (IDE) is properly installed you can go back to the Getting Started Home and choose your board from the list on the right of the page

Fig.7.1 Gas Leakage Level-Normal

RESULTS AND DISCUSSION

Gas level displayed is normal and the percentage of the gas is showing on the LCD display. Here the gas level is 89; it means there is no gas leakage. Here we have kept the base value of 100.

In this case gas level displayed is exceeding and the percentage of the gas is showing on the LCD display. Here the gas leakage level exceeds 100, so the alert message is sent to the user with the help of the GSM module
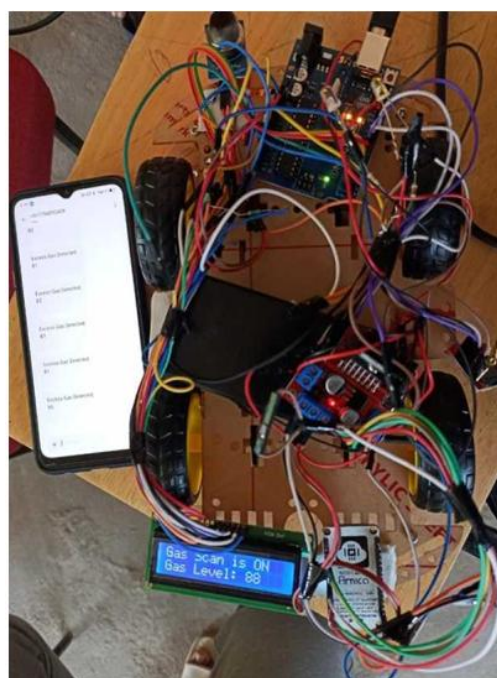

Fig.7.2 Gas Leakage Level-High

Fig.7.3 Alert Message When Gas Leakage Is Displayed

CONCLUSIONS AND FUTURE SCOPE

It is implemented Gas Leakage detection system by using Arduino Uno, NodeMcu, MQ-9 gas sensor, LCD Display. While implementing the project we learn lot about Arduino, Gas sensors, Nodemcu and many other IoT devices. Gas Leakage leads a huge problem in many industries and households. We are going to design such a robot that can detect Gas Leakages effectively by using a MQ-9 gas sensor and alert user by sending an alert message by using the GSM800C module to the respective mobile phones. Hence our Project will definitely prove to be an important for households and industries.

This is a low-cost, low-power, lightweight, safe, user-friendly, efficient, multi-featured, and simple system for detecting gas. A gas detector will not only provide us with significant information for the health department but it will also leads to a significant increase in our economy because when gas leaks, it not only contaminates the atmosphere but also wastes of gases will hurt our economy. The sensor was calibrated, and the program was then run to get the particle per million values. To ensure that the gas levels being detected by the sensor are accurate, the calibration and preheating of the sensor are done. When the system is running, the data from the sensor is uploaded to the webserver. The data collected is in real-time and will display the concentrations of the gases. Buzzer and LED were used as audible and visual alarms. When the concentration of gas crosses a threshold, a buzzer and lead will trigger. When the buzzer and LED light up and send out a text alert to the user via Smartphone

Future scope

In Future research it is planning to upgrade project with robotic arm technology that will used for reaching to the heights of pipeline vertically. The camera module and display sensor will also be implemented in the project so rover can be used for underground and tunnel.

One of the significant functions of the system in the future is to add a subsystem that can monitor gas waste and gas usage systems. The system will have a function to notify emergency services if any accidents occur. In the future, a system will be integrated into this one that will provide more safety and relaxation to the users.

The proliferation of handheld devices has led to developments in the field of smart gas sensors that have increased their scope of application. Safety will be needed in workplaces, so the market will grow over the coming years.

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