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A Novel Sensor-Based System for Detecting LPG Leakage Using Game Theory

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ABSTRACT:

Gas leakage detection is crucial for safety in residential and industrial settings. Traditional systems often suffer from false alarms and delays. This paper introduces a game theory-based approach, using the Chicken game concept to enhance decision-making. By treating MQ-6 sensors and suppliers as strategic players, the system improves detection accuracy and minimizes false positives. Implementing ESP32-based hardware, our model ensures faster and more reliable alerts. Experimental results show improved efficiency over conventional methods. Future work will explore AI-driven automation for smarter gas detection.

Keywords: *Gas Leakage, Game Theory, Chicken Game, LPG Leakage Detection*

Introduction

Liquefied Petroleum Gas (LPG) is a widely used energy source for domestic, industrial, and commercial applications due to its efficiency, convenience, and relatively lower environmental impact compared to traditional fossil fuels. It consists mainly of propane (C_3H_8) and butane (C_4H_{10}), which are highly combustible gases stored under pressure in liquid form. LPG is commonly used in households for cooking, heating, and hot water systems, while in industrial sectors, it plays a crucial role in manufacturing, metal processing, and chemical industries. Despite its benefits, LPG poses significant safety risks due to its high flammability and potential for leakage, which can lead to fire hazards, explosions, and health risks such as suffocation when inhaled in high concentrations. Traditional gas leakage detection systems rely on threshold-based sensing techniques, where a sensor activates an alarm when gas concentration exceeds a predefined limit.

India is one of the largest consumers of LPG globally, with its demand growing rapidly due to urbanization, rising living standards, and increasing awareness of health and environmental benefits. The clean-burning nature of LPG aligns with the country’s goals of reducing deforestation, lowering carbon emissions, and improving air quality. In addition to household use, LPG is utilized in various industries as an energy source and as an alternative fuel in the transportation sector under the "Auto LPG" initiative, which aims to reduce vehicle emissions. The Indian government has been instrumental in promoting LPG through initiatives like the Pradhan Mantri Ujjwala Yojana which provides subsidized LPG connections to low-income families, especially in rural areas, significantly enhancing accessibility and adoption. In addition, environmental factors such as temperature, humidity, and airflow patterns can affect sensor performance, further reducing accuracy. Moreover, conventional detection systems do not prioritize risk-based decision-making, which is crucial in scenarios where immediate action is required.

Gas leakage refers to the unintended release of gases such as Liquefied Petroleum Gas (LPG), natural gas, methane, and other industrial gases into the surrounding environment. This leakage can occur due to various reasons, including faulty pipelines, damaged gas cylinders, improper handling, or mechanical failures in gas storage and transportation systems. Gas leakage poses serious hazards to both human life and property, as these gases are often highly flammable, toxic, or suffocating when present in large concentrations. Gas leaks can occur in households, industries, and transportation systems. Gas Leage is one of the major and complicated faced all over the world. In homes, LPG leaks are common due to loose cylinder connections, leaking hoses, or unattended cooking stoves.

In industries, gases such as methane, hydrogen, ammonia, and carbon monoxide may escape from chemical plants, oil refineries, and factories, leading to health hazards and environmental pollution. Additionally, natural gas pipeline leaks are a significant issue, as they contribute to greenhouse gas emissions and pose explosion risks.

Most gases used for cooking, heating, and industrial applications are highly flammable. When leaked gas accumulates in a confined space and comes into contact with an ignition source (such as a spark, flame, or high heat), it can lead to a massive explosion. Some of the major disasters in history, such as the Ghislenghien gas explosion in Belgium (2004), occurred due to unnoticed gas leaks. Key Risks: High risk of fire outbreaks in residential and industrial settings. Gas explosions can lead to fatalities and extensive property damage. Even small leaks, if left undetected, can cause suffocation in enclosed spaces. Certain gases, when leaked, pose serious health risks due to their toxicity and asphyxiating properties. For example: Carbon Monoxide (CO) is a colorless, odorless gas that can cause dizziness, unconsciousness, and even death when inhaled in large quantities. Methane (CH_4) displaces oxygen, leading to breathing difficulties and possible suffocation. Ammonia (NH_3) and chlorine (Cl_2) leaks from industries can result in skin burns, lung damage, and chronic illnesses. Health Effects of Gas Exposure: Short-term exposure can cause nausea, headaches, dizziness, and breathing issues. Long-term exposure can lead to respiratory diseases, neurological disorders, and cancer. In extreme cases, exposure to certain gases may cause fatal poisoning. Gas leaks are not only a safety hazard but also a major cause of environmental degradation.

- Methane leaks contribute significantly to global warming as methane is a potent greenhouse gas, approximately 25 times more effective than CO_2 at trapping heat in the atmosphere.
- Industrial gas leaks result in air and water pollution, harming local ecosystems.
- Gas emissions from industries and oil refineries release volatile organic compounds (VOCs), which contribute to acid rain, smog formation, and ozone depletion.

Key Environmental Concerns:

- Air pollution due to toxic gas emissions.
- Damage to aquatic life when chemicals dissolve into water sources.
- Contribution to climate change due to greenhouse gas emissions.

More dangerously, weakened gas cylinders exposed to impure fuel mixtures become prone to leaks that increase fires and explosions. To prevent such risks, regulatory authorities conduct routine inspections, and consumers are advised to purchase LPG from authorized dealers and stay vigilant about changes in flame color, unusual odors, or excessive residue formation.

II. Problem Statement

Gas leakage detection is a vital aspect of ensuring safety in residential, commercial, and industrial settings. The unintended release of gases such as LPG, methane, or other volatile hydrocarbons poses significant threats, including fire hazards, explosions, and health complications. Gas leaks often occur due to poor maintenance, aging infrastructure, mechanical failures, or accidental damage to pipelines and storage tanks. If left undetected, even minor leaks can escalate into catastrophic incidents, leading to loss of life, property damage, and severe environmental consequences. Additionally, undetected leaks contribute to greenhouse gas emissions, further exacerbating global warming. As the reliance on gaseous fuels continues to grow, addressing the risks associated with leaks has become an urgent priority. The presence of leaked gas in confined spaces disrupts the oxygen balance, increasing the likelihood of asphyxiation. Prolonged exposure to leaking gases such as carbon monoxide and methane can lead to serious health issues, including respiratory distress, dizziness, nausea, and, in severe cases, fatal poisoning. The flammable nature of LPG and natural gas further heightens the risks, as even a small spark can ignite an explosion. Households and industries relying on gas-powered equipment often face operational inefficiencies and frequent maintenance challenges when undetected leaks lead to incomplete combustion. Moreover, gas leaks also corrode pipelines and burners over time, reducing the lifespan of appliances and infrastructure. Beyond personal safety concerns, gas leakage incidents have broader implications for industrial operations and environmental sustainability. Industries using large volumes of gaseous fuels must adhere to stringent safety regulations to prevent workplace hazards and minimize emissions. Gas leaks contribute to air pollution, ozone layer depletion, and climate change by releasing methane and other harmful hydrocarbons into the atmosphere. Inadequate detection and delayed response to leaks can lead to massive industrial accidents, causing not only economic losses but also long-term environmental degradation. Given these serious repercussions, a proactive approach to leak detection is essential to maintaining safety and sustainability. To combat these risks effectively, the development of an advanced Gas Leakage Detection System is essential. This system would employ state-of-the-art sensor technology to detect gas leaks in real time by continuously monitoring gas concentration levels and identifying anomalies.

The system would be equipped with multiple sensors capable of detecting even trace amounts of leaked gases, ensuring early warning alerts before a critical situation arises. By integrating this detection mechanism with smart technology, it would be possible to send instant notifications to users, safety personnel, and relevant authorities, enabling timely action to prevent disasters. A sensor-based gas leakage detection system would significantly enhance safety standards by providing real-time monitoring, automatic alerts, and preventive actions. The implementation of such a system in homes, businesses, and industrial plants would reduce fire hazards, lower emissions, and improve the efficiency of gas-powered systems. Additionally, this technology would help regulatory agencies enforce safety standards and hold suppliers accountable for gas quality and infrastructure maintenance. By adopting a sensor-driven gas leakage detection approach, we can mitigate risks, enhance operational efficiency, and ensure a safer environment for all stakeholders. This proactive solution represents a crucial step toward improving gas safety measures and fostering responsible fuel usage.

What is Game theory:

Game theory is a branch of mathematics and economics that studies the strategic interactions between two or more decision-makers, referred to as players, in a given situation. It provides a framework to analyze how individuals or organizations make decisions when the outcome of their choices depends not only on their own actions but also on the actions of others. Game theory is widely used in various fields such as economics, political science, biology, psychology, computer science, and engineering to understand competitive and cooperative behaviors. The primary objective of game theory is to predict the optimal decisions that rational players would make in different scenarios, aiming to maximize their own benefits while considering the possible strategies of others. The fundamental concepts of game theory include players, strategies, payoffs, and equilibrium outcomes. Each player involved in the game has a set of possible actions or strategies to choose from, and the outcome of the game is determined by the combination of all players' choices. The payoff represents the reward or benefit that a player receives based on the combination of strategies selected by all players. The interactions between players can be either cooperative or non-cooperative, depending on whether they agree to collaborate or act independently in pursuit of their own interests. One of the most significant outcomes in game theory is the Nash equilibrium, named after mathematician John Nash. It represents a situation in which no player can improve their payoff by unilaterally changing their strategy.

III. Literature Survey

Gas leaks have been responsible for some of the most devastating industrial and environmental disasters in history. From toxic gas leaks in chemical plants to methane explosions in mines, these incidents have resulted in mass casualties, severe health impacts, and long-term environmental damage. Poor maintenance, weak safety regulations, and inadequate response systems often contribute to these tragedies. Here are some tragedies that happened worldwide which were very dangerous.

Bhopal Disaster (India, 1984)

The Bhopal gas tragedy is considered one of the worst industrial disasters in history. On December 2-3, 1984, a methyl isocyanate (MIC) gas leak from the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, India, exposed over 500,000 residents to the toxic gas. The immediate death toll was estimated at 2,259, but the long-term impact led to over 16,000 deaths and severe health complications for thousands. Survivors suffered from blindness, respiratory issues, and birth defects for generations. The disaster was caused by poor maintenance, lack of safety protocols, and cost-cutting measures. To this day, legal and environmental battles continue over the contamination at the site. Source: Wikipedia

Hlobane Coal Mine Explosion (South Africa, 1983)

On September 12, 1983, the Hlobane Colliery coal mine in South Africa experienced a devastating methane gas explosion. The explosion occurred due to poor ventilation, which allowed flammable gases to accumulate in the mine. As a result, 68 miners lost their lives in the underground explosion. Investigations revealed that safety regulations were ignored, and miners were not properly trained to detect gas buildup. This tragedy led to increased worker safety awareness and stricter mining regulations in South Africa. Source: Wikipedia

Piper Alpha Disaster (North Sea, 1988)

The Piper Alpha disaster was one of the deadliest offshore oil rig accidents in history. On July 6, 1988, a gas leak led to an explosion on the Piper Alpha oil platform in the North Sea, operated by Occidental Petroleum. The explosion ignited a massive fire, which spread rapidly, causing the platform to collapse within two hours. Out of 226 crew members, 167 died, while only 59 survived. The investigation found that a safety valve was removed for maintenance, but workers were not informed, leading to a gas release and subsequent explosion. This disaster resulted in major changes in offshore safety regulations, including better evacuation plans and improved safety systems. Source: Wikipedia

Gas leakage detection has been a critical area of research due to its impact on safety, environmental hazards, and economic losses. Several studies have explored different methodologies for detecting gas leaks, including sensor-based monitoring, artificial intelligence, and network-based detection systems. Additionally, game theory has been applied to optimize safety strategies, risk assessment, and decision-making in gas leakage scenarios.

1. Gas Leakage Detection Research

- **Precision Gas Leakage Detection System with Integrated Sensors**

This study presents a gas leak detection system that utilizes mobile technology to integrate phone calls, SMS, WhatsApp, and GPS location services. The system also features an automatic power supply shut-off in the affected area. The prototype was tested with gases such as butane and propane, demonstrating detection capabilities in less than a minute.

- **IoT-Based Intelligent Gas Leakage Detection and Fire Protection System**

This research focuses on designing and implementing an intelligent IoT prototype to detect gas leakage and associated fires. The system employs gas sensors, solenoid valves to shut off gas lines, exhaust fans, flame sensors, and GSM modules to notify users via smartphones. The system aims to minimize the effects of gas leakage by taking protective measures.

- **Early Detection System for Gas Leakage and Fire in Smart Homes Using IoT**

This paper presents an IoT-based gas leak detection system designed to improve safety and reduce the risk of gas leakage. The system integrates gas sensors, microcontrollers, communication modules, and cloud computing infrastructure to enable real-time monitoring, data analysis, and remote management. It provides rapid rescue and intervention by sending instant notifications via mobile applications in case of a gas leak.

- **Gas Leakage Detection and Smart Alerting System Using IoT**

This research focuses on developing an IoT-based gas leakage detection system that not only detects the presence of hazardous gases but also provides smart alerts to users. The system integrates gas sensors, microcontrollers, and communication modules to monitor gas levels in real-time.

Upon detecting a leak, it sends notifications via mobile applications and activates safety mechanisms like shutting off gas supply valves. The study emphasizes the importance of timely alerts and automated responses to prevent potential hazards associated with gas leaks.

2. Game Theory in Safety Systems

Game theory has been increasingly applied in the safety and risk assessment of hazardous systems. The following research studies highlight its role in gas leakage prevention:

- **Strategically Patrolling in a Chemical Cluster Addressing Gas Pollutants Releases through a Game-Theoretic Model**

The research investigates how to optimize patrol strategies within a chemical cluster to address potential gas pollutant releases effectively. The study employs a game-theoretic model, which likely involves analyzing the interactions and decision-making processes of different actors (e.g., patrol teams, and potential polluters) to find the most effective patrol strategies.

- **Bayesian Network and Game Theory Risk Assessment Model for Third-Party Damage to Oil and Gas Pipelines**

This study combines Bayesian networks with game theory to assess the risks of third-party damage to oil and gas pipelines. It distinguishes between unintentional damage and malicious attacks, enhancing security measures. The game theory approach is used to model malicious disturbances and create and sort out various security-related risk scenarios.

- **Application of Game Theory in Risk Management of Urban Natural Gas Pipelines**

This study presents a game-theoretic methodology for risk management of urban natural gas pipelines, involving stakeholders such as government bodies, pipeline companies, and the public. The approach estimates stakeholder involvement using static game theory and employs system dynamics simulation to analyze the evolution of risk management strategies under various conditions.

- **A Game Theory-Based Multi-Layered Intrusion Detection Framework for Wireless Sensor Networks**

This research proposes a multi-layered intrusion detection framework for wireless sensor networks (WSNs) using game theory. It has employed in monitoring industrial environments, including gas pipelines. The study utilizes Bayesian game models and Shapley value concepts to enhance the detection and prevention of intrusions in such networks.

IV. Proposed Solution

Ensuring the identification of LPG leakage is crucial for household safety. To illustrate the functionality of our system, a structured flowchart has been designed, providing a clear representation of the detection and alert mechanisms implemented.

According to the flowchart, the proposed system integrates both hardware and software components to ensure the safety and quality of Liquefied Petroleum Gas (LPG) used in households. The workflow is structured as follows:

User Registration & Profile Setup

The workflow begins with the user registration and profile setup through the system's software interface. Customers must sign up by providing their name, phone number, email, and address. This step helps create a personalized profile for each customer, allowing the system to send alerts and notifications directly to the registered contacts. After registration, users can place an order for the hardware device. Once the hardware is delivered, users must enter the Reference ID into the software to activate and pair the device. The system then notifies the user when the device is successfully linked. Existing users can log in to access updates, news, and instructional reference videos to better understand the device's functions.

Device Functionality & Monitoring

The functionality and monitoring of the proposed gas leakage detection system are critical to ensuring safety in residential, commercial, and industrial environments. The system incorporates an MQ-6 gas sensor, which continuously monitors the surrounding air to detect the presence of leaked Liquefied Petroleum Gas (LPG) or other flammable gases such as propane and butane. The sensor is integrated with an ESP32 microcontroller, which processes real-time data and activates safety mechanisms when a leak is detected. Upon detecting gas concentrations exceeding the predefined safety threshold, the sensor immediately triggers an alarm system. The buzzer is activated to alert occupants, and the LCD display provides a visual warning. Simultaneously, the system sends real-time notifications to registered users via a mobile application. If the initial alert is not acknowledged, secondary alerts are sent to alternative emergency contacts and the local gas supplier to ensure immediate intervention.

The system is designed for continuous real-time monitoring, reducing the risk of undetected leaks. It also integrates remote monitoring features, allowing users to access gas concentration data through a cloud-based platform. This enables proactive safety management, preventing hazardous situations before they escalate.

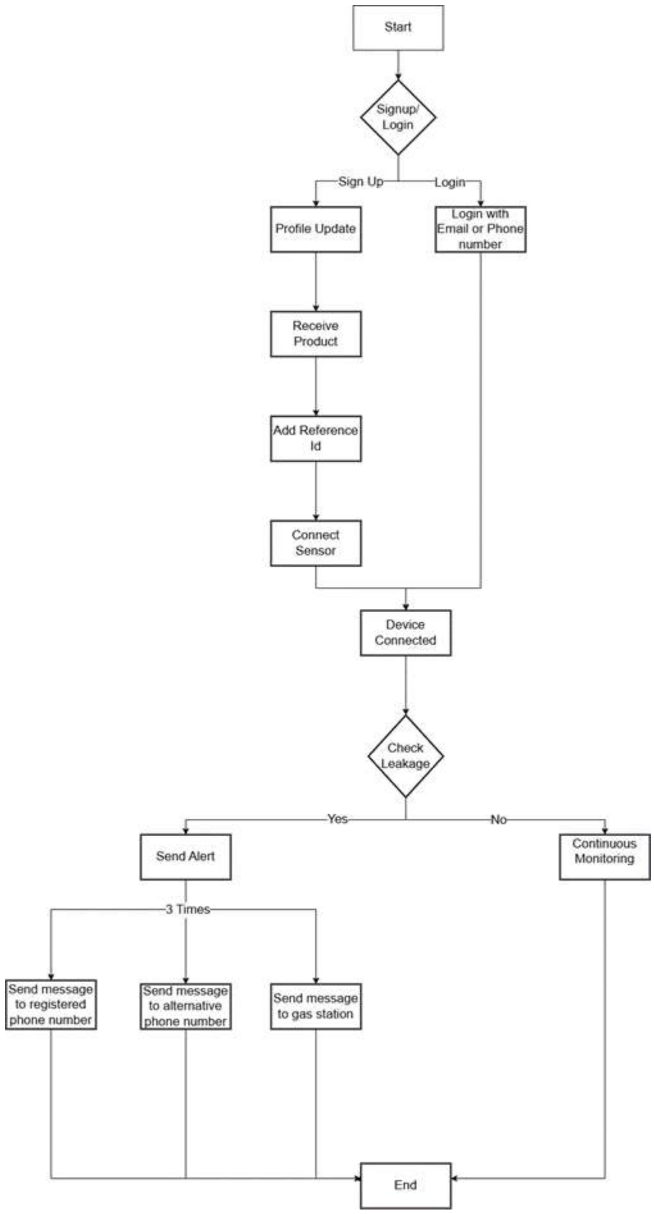

Fig 4.1 Flowchart

Alert mechanism and Notifications

The alert mechanism and notification system are critical components of the proposed gas leakage detection system, ensuring rapid response to potential hazards. The system integrates automated alert functionalities using both hardware alarms and software notifications, enhancing safety while minimizing human intervention. For gas leakage detection, the system utilizes the MQ-6 sensor, which continuously monitors the environment for LPG leaks. If a leakage is detected, the system immediately triggers a buzzer alarm, providing an audible warning to alert individuals within the household. Simultaneously, the system sends real-time notifications through the ESP32's Wi-Fi module to the customer's registered phone number, an emergency contact, and the local gas supplier

This multi-tiered notification system ensures that both the user and external support services are informed without delay, facilitating prompt intervention. To enhance reliability, the system includes an alternative emergency contact, ensuring that alerts reach the appropriate recipients even if the primary user is unavailable. This automated alert process significantly reduces response time, mitigating the risks associated with gas leaks. Additionally, the system is designed for continuous operation, seamlessly resetting and resuming real-time monitoring once the leakage is resolved. The notification system follows a hierarchical messaging approach, prioritizing alerts based on the severity of the hazard. This structured alert mechanism enhances household safety by ensuring timely action while also improving coordination between users and gas suppliers. By integrating hardware-based alarms with IoT-enabled notifications, the system offers 24/7 monitoring, making it a reliable and user-friendly solution for gas safety assurance.

The Chicken Concept in Game Theory

The Chicken Game involves two players who are engaged in a high-risk confrontation, where each must decide whether to back down (swerve) or continue their aggressive stance (stay straight). The most well-known analogy is two drivers speeding toward each other on a collision course. If one driver swerves while the other stays straight, the driver who swerves is seen as the "loser" (or "chicken"), while the one who stays straight is perceived as dominant. However, if both drivers refuse to swerve, they crash into each other, leading to disastrous consequences for both. On the other hand, if both swerve, neither gains an advantage, resulting in a neutral outcome. The game creates a situation where both players want to maintain a strong stance, but the fear of mutual destruction forces at least one of them to yield. This setup applies beyond reckless driving, as it models various real-world conflicts where two opposing sides must decide whether to de-escalate or risk severe losses.

Player1/ Player 2	**Back-down**	**Stay Straight**
Back-down	Both avoid collision (Neutral outcome)	Player 1 loses (Backs down, seen as weak)
Stay Straight	Player 1 wins (Holds position, Player 2 backs down)	Both crash (Worst outcome, mutual destruction)

Table 4.1 Chicken Game

In the Chicken Game, two players engage in a strategic decision-making process where they must choose between two actions: back down or stay straight. The outcomes depend on the decisions made by both players simultaneously.

- If both players choose to back down, they avoid conflict, leading to a neutral outcome where neither wins nor loses (0,0).
- However, if Player 1 backs down while Player 2 Stays Straight, Player 1 is seen as the weaker competitor and known as chicken, while Player 2, who held their ground, is considered the winner.
- On the other hand, if Player 1 Stays Straight and Player 2 backs down, the roles reverse—Player 1 wins and Player 2 loses for backing down.
- The most disastrous outcome occurs when both players choose to Stay Straight, refusing to yield. In this scenario, neither player backs down, resulting in a collision or catastrophe), which is the worst possible consequence.

This game represents high-stakes decision-making, often seen in competitive or risky real-world scenarios where mutual cooperation or stubbornness can lead to either safety or disaster.

Application of Chicken Game in Gas Leakage Detection

Gas Suppliers (distributors, companies, authorities) and Leak Detection Systems (sensors, automated monitoring, emergency response).

Game Setup Based on Your Flowchart

1. Players:
    - Gas Supplier (LPG Provider, Distributor)
    - Leak Detection System (Sensors, ESP32, Alert Mechanism, Authorities)
2. Strategies Available:

Gas Supplier:

Act Responsibly (Swerve): Ensure gas supply safety, respond to leakage alerts, and take corrective actions.

Ignore Safety Measures (Stay Straight): Neglect safety concerns, leading to dangerous consequences.

Leak Detection System:

Trigger Emergency Alerts (Swerve): Notify users and authorities, forcing corrective action.

Delay Response (Stay Straight): Assume the supplier will act, risking hazardous incidents.

	Supplier Responds	**Supplier Ignores**
Detection System Alerts	Safety Ensured, No Damage	Public Alert, Supplier Penalized
Detection System Waits	Delay in Action, Higher Risk	Major Disaster (Worst Outcome)

Table 4.2 Chicken Game Application in Leakage Detection

When the MQ-6 Sensor detects leakage, it forces the supplier into action through alerts.

If the supplier responds → Immediate safety measures, prevent an explosion.

If the supplier ignores → The alert system escalates (notifying emergency services and authorities).

If neither acts → Disaster occurs, leading to explosions, deaths, and legal action.

The Chicken Game serves as a powerful model for understanding competitive decision-making in high-stakes situations. It highlights how strategic interactions between two opposing players can lead to either cooperation or disaster, depending on their willingness to yield. The game underscores the importance of psychological factors, such as perception, trust, and risk tolerance, in shaping outcomes. In real-world applications, it is evident in international conflicts, business rivalries, traffic behavior, and economic negotiations, where decision-makers must carefully evaluate their choices to avoid mutual destruction. The key takeaway from the Chicken Game is that while standing firm can sometimes lead to victory, excessive stubbornness can cause catastrophic consequences. Therefore, rational decision-making, negotiation, and a calculated assessment of risks are crucial for achieving the most favorable outcome.

By applying the Chicken Game, your gas leakage detection system creates a self-enforcing safety mechanism, ensuring that gas suppliers cannot afford to ignore leaks—forcing them to act before disasters occur.

V. Conclusion

Gas leakage detection is a crucial aspect of ensuring safety in residential, commercial, and industrial environments. The risks associated with undetected gas leaks, such as fire hazards, explosions, health complications, and environmental damage, emphasize the need for an efficient and proactive detection system. By integrating advanced sensor technology, IoT-based monitoring, and real-time alert mechanisms, the proposed system enhances safety, minimizes human intervention, and ensures rapid response in case of leakage.

The proposed system, as illustrated in the flowchart, follows a structured approach to gas leakage detection and response. It begins with continuous monitoring using MQ-6 sensors, which detect the presence of LPG in the air. If leakage is detected, the system triggers an immediate response, including a buzzer alarm, LCD notification, and real-time alerts sent via Wi-Fi to the user, an emergency contact, and the gas supplier. This hierarchical notification system ensures that the issue is escalated if the user fails to respond, ultimately reaching emergency services if required. Additionally, the system operates in a looped mechanism, ensuring 24/7 monitoring and automatic resets when normal conditions are restored. This structured process significantly improves safety by enabling quick detection and response, preventing potential disasters.

The application of game theory, particularly the Chicken Game, provides a strategic framework for understanding decision-making in gas safety. It illustrates the interaction between key stakeholders—users, suppliers, and regulatory authorities—where conflicting interests must be balanced to avoid catastrophic consequences. In the flowchart's context, the gas supplier and the end-user act as the primary players. If the supplier fails to act on leakage alerts (choosing to "stay straight"), it could lead to hazardous incidents, just as in the Chicken Game, where neither player swerves, resulting in a crash. Conversely, if both parties respond appropriately (choosing to "swerve"), safety is ensured, and disaster is prevented. This strategic approach highlights the importance of cooperation, accountability, and quick decision-making in mitigating gas leakage risks. Moreover, this study highlights how technological advancements, such as smart gas sensors, AI-driven data analytics, and cloud-based monitoring, can revolutionize the safety landscape. These innovations not only detect gas leaks in real time but also facilitate automated responses, predictive maintenance, and efficient resource management, reducing the likelihood of accidents. The integration of multi-tiered alert mechanisms, emergency contact notifications, and supplier accountability ensures that any detected leaks are addressed swiftly, preventing disasters before they occur.

By leveraging both technology and strategic decision-making principles, the proposed system contributes to a safer, more sustainable, and efficient energy infrastructure. Implementing such solutions will protect lives, reduce economic losses, and ensure compliance with safety regulations, ultimately fostering a more responsible and secure gas supply network for consumers.

<u>Advantages</u>

Early Warning System

The system detects gas leaks in real-time and provides instant alerts, preventing potential disasters.

Automated Alerts & Notifications

Uses buzzer alarms, mobile notifications, and emergency alerts to inform users, emergency contacts, and suppliers about leaks.

24/7 Continuous Monitoring

Ensures uninterrupted gas detection without requiring manual checks, making it highly reliable.

User and Supplier Accountability

The Chicken Game theory application encourages both users and gas suppliers to take responsibility for safety, reducing negligence.

Prevention of Fire and Explosion Hazards

Minimizes fire, explosion, and suffocation risks by detecting gas leaks before they reach dangerous levels.

Cost-Effective & Efficient

Reduces economic losses from gas-related accidents, property damage, and medical emergencies.

IoT and Smart Integration – Uses ESP32 microcontroller and Wi-Fi connectivity for cloud-based monitoring, making it accessible from mobile devices.

Scalability & Adaptability

Can be implemented in households, industries, restaurants, and commercial spaces with ease.

Environmental Protection

Prevents greenhouse gas emissions by reducing undetected gas leaks that contribute to climate change.

User-Friendly & Low Maintenance

Simple setup with minimal human intervention, making it ideal for everyday use.

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