

Smart Chemical Material Store System Using IOT and Raspberry PI

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Abstract

Within the period of savvy innovation, the administration of chemical capacity postures critical challenges, especially in guaranteeing security and natural compliance. This paper plan and usage of a keen chemical capacity framework utilizing Raspberry PI presents an imaginative arrangement to this squeezing issue by leveraging the capabilities of Raspberry PI4 and the Web of Things (WoT) innovation. This investigate expresses the advancement and sending of a exceedingly productive, cost-effective shrewd chemical capacity framework outlined to optimize security, energy saving and protecting the internal and external environment of the store from air pollution. By coordination sensors for identifying different chemical gasses, temperature, mugginess, and pH levels, washing column, the framework gives real-time information examination, guaranteeing a responsive and energetic approach to chemical capacity administration. The Raspberry PI4 serves as the central handling unit, coordinating information procurement, processing, and decision-making forms to preserve ideal capacity conditions and preemptively address potential risks. Through the utilization of K-Means Calculation for information investigation, the framework illustrates extraordinary capability in recognizing and cautioning to dangerous conditions, in this way essentially decreasing the hazard of chemical mishances and processed. The usage exhibits a versatile, versatile system that obliges the expansion of different sensors and gadgets, encouraging a comprehensive observing arrangement custom-made to the particular needs of chemical capacity offices. This investigate not only contributes to the field of chemical security but moreover sets a point of reference for the application of savvy advances in mechanical security administration, advertising experiences and techniques that can be adjusted over assorted segments.

Keywords- Chemical Materials, Sensors, K-Means Algorithm, Smart Storage System, Raspberry PI4B.

I. INTRODUCTION

Chemical Storage presents interesting challenges, counting the ought to always screen natural conditions, distinguish emanations of unsafe gasses, and guarantee compliance with security controls[1][2]. Conventional capacity frameworks frequently come up short to comprehensively address these challenges, driving to expanded dangers of mishaps and wasteful aspects in chemical administration[3]. Joining shrewd advances into chemical capacity frameworks gives a promising arrangement to these challenges, leveraging real-time observing and mechanized control to improve security and operational productivity[4][5].

This consider is imperative for a few reasons. To begin with, it addresses a basic hole in chemical capacity administration by advertising an cleverly framework competent of real-time natural observing, unsafe gas location, and robotized control[6][7]. Utilizing the Raspberry Pi [8]. as the center preparing unit underscores the possibility of actualizing high-tech arrangements in a cost-effective way [9]. Moment, the think about contributes to the body of information on the application of Web of Things (WoT) innovation in mechanical security and natural checking[10]. At long last, by illustrating the commonsense usage of the framework, the consider gives profitable bits of knowledge for businesses looking for to upgrade their chemical capacity offices with shrewd advances [11].

The consider strategy rotates around the plan and usage of a shrewd chemical capacity framework [12], centering on the integration of sensors, Raspberry Pi and IoT innovation to realize real-time checking and control[13]. The framework employs an assortment of sensors to screen natural conditions such as temperature, mugginess, and gas concentrations inside the capacity office[14][15]. The Raspberry Pi acts as a central handling unit, analyzing information from sensors and starting fitting reactions to preserve secure capacity conditions [16][17] The usage handle is point by point, from framework plan to equipment setup and program setup, giving a comprehensive direct to imitating the framework in real-world settings [18][19].

Offers an inventive approach to chemical capacity administration that upgrades security and effectiveness through the utilize of savvy advances. The think about too gives a viable case of applying Raspberry Pi and IoT innovation in an industrial environment, illustrating the potential of these innovations to convert conventional frameworks. Moreover, the point-by-point introduction of the framework design and execution prepare serves as an important asset for analysts and specialists inquisitive about creating comparable arrangements.

The investigation separated into a few areas. The “Related Work” segment audits the existing writing on savvy capacity frameworks and the application of IoT innovation in chemical capacity, highlighting the oddity of the proposed framework. The Prerequisites segment characterizes the technical specifications and components of the system, giving a premise for understanding its plan and usefulness. The Equipment Execution area subtle elements of the framework setup, from sensor integration to computer program setup. The “Results” segment assesses the execution of the framework, illustrating its adequacy in real-time monitoring and computerized control and processed. The paper concludes with a discourse on the suggestions of the think about for future investigations and commonsense applications in chemical capacity administration.

II. RELATED WORK

In 2021, Maha Khalil Ibrahim et al. [20] developed an intelligent system for monitoring the storage of ammonium nitrate. Their system has three components: The Warehouse Monitoring Part (WMP), the Chemical Control System (MCS) part, and the third part is the Emergency Part (EP). The MCS comprises many hardware components, Ds18b20 sensor, Arduino microcontroller, GSM, MQ sensors, GPS, LCD, and buzzer. The researchers devised two alarm devices, the first alerts WMP when the chemical storage temperature reaches a threshold. Second, EP. It receives the alarm and locates the gas leak that might cause a fire or explosion. Also, the buzzer listens and displays the sensor status on the LCD screen. The system employs the Object-Oriented Software Engineering (OOSE) methodology, utilizing the Unified Modelling Language (UML).

In 2022, R Macías-Quijas et al., [21], introduced a tiny and economical electronic nose(e-nose) that detects airborne toxins using metal oxide semiconductor(MOS) sensors and filter diagonalization technique (FDM). The gadget is versatile and may be utilized in a range of environments, such as indoor facilities, public transit, mobile robotics, and wireless sensor networks. E-noses include six MOS sensors on plastic bases that alter resistance when exposed to gas. A mesh-like structure filters suspended particles, letting only gaseous components into the sensors. The prototype further more incorporates an electrical module using a microprocessor for the purpose of signal gathering, USB connectivity with a computer, and control over an air pump.

Mohammed Faeik Ruzaij Al-Okby and others in 2022 [22]coordinated a commercial MOX gas sensor, SGP41, into an IoT natural sensor hub to identify and caution of perilous gasses. The analysts appeared that the sensor identified a few parameters, counting the nitrogen oxide list (NOx-Index) and the unstable natural compounds file (VOC-Index). The analysts conducted a few tests to identify the spillage of nitrogen oxides and unstable natural compounds at distinctive concentrations and sizes, as well as from distinctive spillage separations to degree the impact of these components on the reaction speed and recuperation time of the sensors utilized. They compared these variables between diverse sensors coordinates into the sensor hub to deliver a comprehensive picture of the framework being utilized. Framework test comes about appears that the SGP41 sensor is able to perform the plan purposes for the target parameters, can identify little NO₂ spills beginning at 0.3% volume, and can identify all tried VOC solvents $\geq 100 \mu\text{L}$.

In 2023, Shrote, Jyoti N., and Janardan A. Pawar [23], designed a real-time intelligent air pollution monitoring system based on Raspberry Pi and the Internet of Things and used other necessary hardware such as a 5VDC power supply, LCD, and various commercial gas sensors, such as MQ 2, MQ 5, MQ 7, MQ 9, MQ 135, and TGS 825 are used in the system to detect gases such as LPG, CO, CH₄, CO₂, and H₂S, for the combined system. The storage real-time data and sent it using Thing speak via the cloud. The proposed system provides accurate data in real-time, in addition to that the connected devices must be able to connect to the Internet, and the results are displayed on the LCD screen.

In 2023, Satea Hikmat Alnajjar and Haneen Mohammed Mahmoud [24], developed an air pollution monitoring system using the Internet of Things (IoT) and Visible Light Communications (VLC) over Light Fidelity (Li-Fi). The system uses an MQ135 sensor and a dust module sensor to measure pollutant data in an indoor environment. The ESP32 module transfer sensor data to the Thing Speak cloud from an Arduino microcontroller. The Thing Speak web application enables using to monitor air pollution levels using the VLC system. Software called Optisystem V18 simulates how a web application link might be transmitted to a user fiber-optic channels(FOC) free space channels (FSO) linked with visible light communication(VLC). Researchers evaluated system performance using quality factor and bit error rate(BER) under dusty weather conditions at various distance. The VLC technology demonstrated its capability to transmit high-speed data that meets user requirement in dusty conditions over distances of up 1300 meters.

Raduan Sarif and others in 2024 [25], The gas detection system was enhanced by including two new gas sensors, ENS 160 and TED 110, Which are based on metal semiconductors(MOX) and primarily detect volatile organic chemicals. Researchers employed air quality index and VOC sensors. The sensors parameter was assessed using 12 volatile organic compounds. Their investigation found that TED 110 sensors detected 24 gas samples out of 72, a33% detection rate. Out of seventy gas samples, the ENS 160 sensor demonstrated exceptional performance by detecting sixty. The ENS 160 achieved an average detection rate of 83%.

In 2024, Mohamed A. Fayyad et al. [26] studied the effects of FIPs approach and nanoparticle addition in renewable fuel blends on CRDI diesel engine NO_x emissions, PM size distribution, and soot oxidation. They evaluated a 10% butanol,20% microalgae biodiesel, and 70%diesel combination called M20B10.The study revealed that adding Al₂O₃ and TiO₂ to the M20B10 lowered BSFC by 22.84% and 21.28% and improved BTE by 2.35% and 4.46% for varied engine loads. Compared to the M20B10+Al₂O₃ mix, the M20B10+Al₂O₃ and HFIP blend increased fuel consumption by 21.28% and BTE by 9.63%. Nevertheless, the addition of HFIP resulted in 24.73% rise in NO_x emissions, whereas the burning of the M20B10+Al₂O₃ combination caused a reduction in both PM

concentration and number. The researchers observed a notable enhancement in the reactivity of soot oxidation when Al₂O₃ was included into the M20B10 mixture and HFIP was utilized.

III. REQUIREMENTS

The following is a list of system requirements based on the outline of Figure 1 of a smart chemical storage management system:

A. Power Supply:

- AC power supply is required to provide power to the system.
- The DC/DC transformer is used to lower the voltage to 12V and 5V for various components.

B. Processing Units:

- The CPU, referred to as "PI 4B", which most likely refers to the Raspberry Pi 4B, requires a 5V source.
- Arduino UNO, another microcontroller used to manage sensors and possibly for lower-level control tasks.

C. Sensors:

- Multiple gas sensors (MQ135, MQ137, MQ3) to detect various gases, which are linked to an Analog-to-digital converter (ADC) and potentially an Arduino.
- A temperature and humidity sensor, potentially providing environmental data to the system.
- pH sensor to measure the acidity or alkalinity of the solution.
- Buzzer to alert inside the store of an extreme increase in chemical substances.

D. Communication and Control:

- Wi-Fi switches (ifan04, ESP8232), which can be used to remotely control or to switch different parts of the system wirelessly.
- SIM800L(GSM/GPRS) is used to send SMS message for high-risk situation.

E. Battery Management and Storage:

- The battery management system (BMS) is connected to the battery, indicating that the system may have a rechargeable power supply or backup system.
- SD card, which is likely used with Arduino UNO to record data or store configurations.

F. Cooling:

- The fans are connected to the PI and external storage, indicating that the system generates heat and needs active cooling.

G. Actuator:

- External store fans (fan 1, fan 2, fan 3), which may be part of a larger storage system that requires cooling.
- Air Washing column it is manufactured to treat the air from chemical pollutants.

H. Display:

- A screen, likely showing system status, readings from sensors, or user interaction.

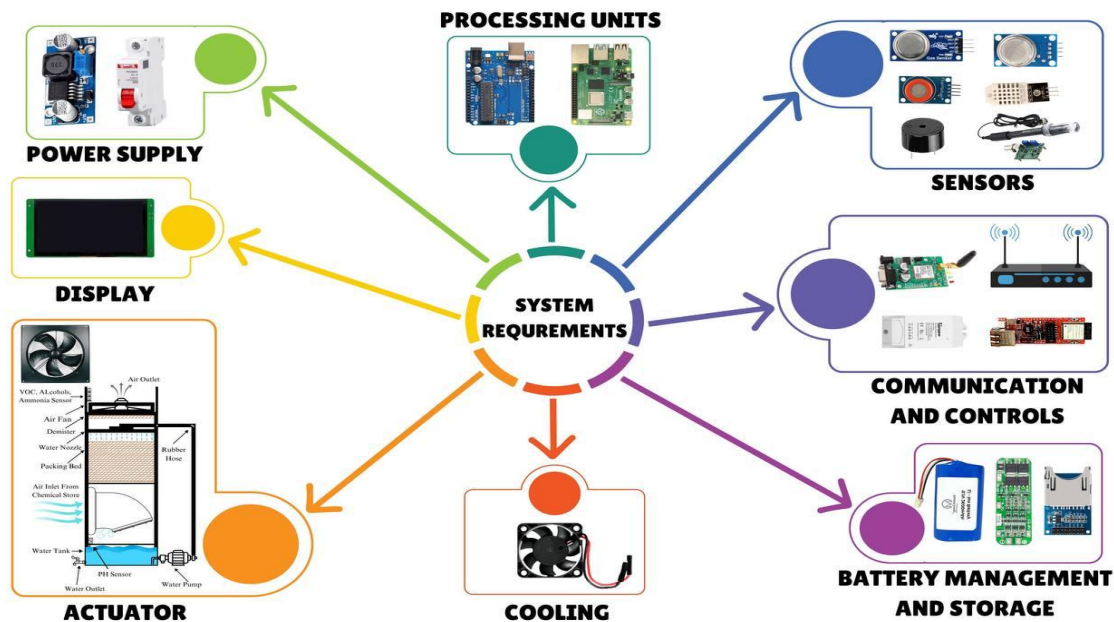


Figure 1, The requirements basic

IV. HARDWARE IMPLEMENTATION

The Real system for the development of an intelligent chemical storage facility utilizing Internet of Things (IoT) and Raspberry Pi 4B draws inspiration from analogous applications of IoT and Raspberry Pi in various sectors, including healthcare, agriculture, and home automation. Figure 2 explains the proposed system implementation design.

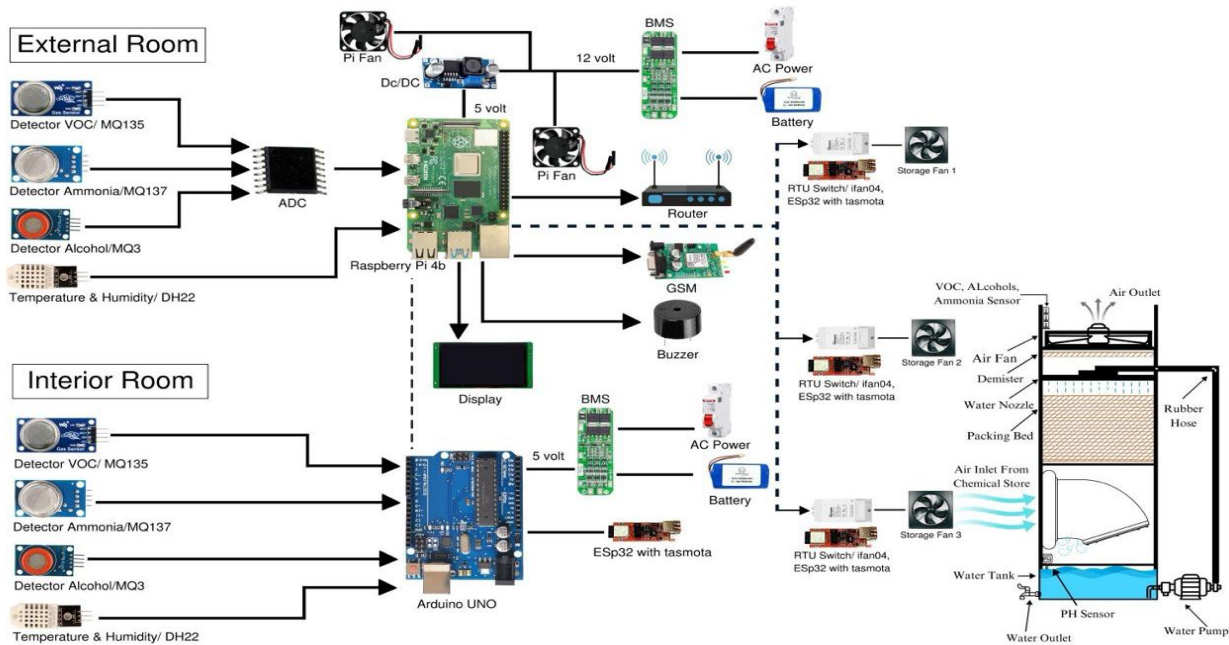


Figure 2, Proposed system.

From the figure above, the connection mechanism for the devices used in designing and implementing a system for a smart chemical store facility with two rooms, one for highly toxic substances. The system consists of four part: chemical materials monitoring system (CMMS) part, store monitoring part (SMP), protection and control mechanism (PCM) part, and emergency part(EP). The Raspberry pi 4B is the core of this system. The design of CMMS part is controlled by PI4 which is connected to the many components: DH22 detector .MQ137 detector, MQ135 detector, MQ3 detector, PI fan, Arduino Uno, LCD, Buzzer, GSM, RTU Switch (ifan04, ESp32 with tasmota), Router.

After collecting summer and winter data through sensors and training it the model using the K-means algorithm and determining the risk ratio 5 cluster, sensors temperature, humidity and gases in real terms and send them to part SMP to determine the severity of the data, if any gas leak is detected a signal will be sent to part PCM by PI4 to RTU Switch and according to the risk ratio, the pullers are controlled to the store, the SMS alarm message will be transmitted to the EP component over the GSM network.

The system is improved by connecting the ventilation system for the highly toxic part of the store to the washing column containing PH, VOC., Alcohol, Ammonia Sensors, Air fan, packing bed, Water pump, Water nozzle, RTU Switch, show in the figure 3 below.

The values of temperature, humidity and gas sensor notifications appear on the LCD.

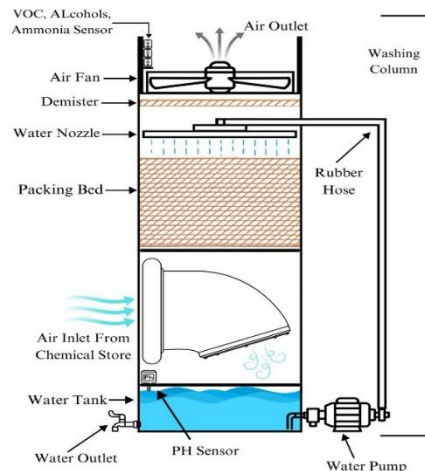


Figure 3, washing column

V. RESULTS AND DISCUSSION

the data from the smart store can be visualized using web flask, with a user interface programmed in python. The interface is specifically built to present real-time information on the temperature, humidity, organic compound vapors, alcohol levels, ammonia level, and PH in the store and utilize the pre-trained model and the k-means algorithm to ascertain the amount of danger associated with substances. The system showcases the remote control of all ventilation fan based on the risk level indicated by the model. The interface also indicates the pace at which polluted air is filtered by the washing column, as shown in figure 4.



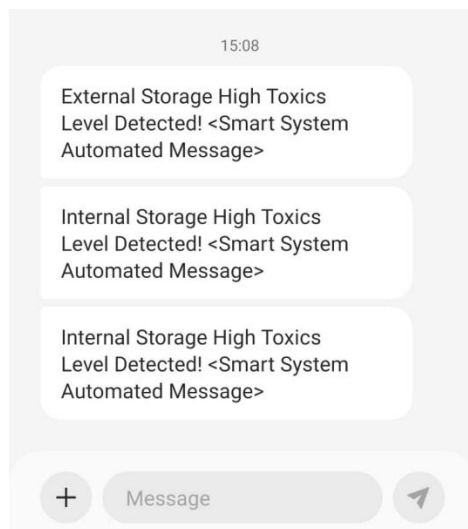
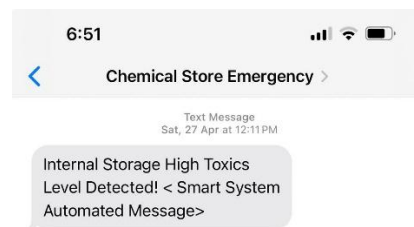
 Chemical Smart Storage 				
Manual Change	Current Value	Sensors (Outer)	Sensors (Inner)	After Purification
Select Fan <input type="radio"/> Inner Storage <input type="radio"/> Outer Storage Select Speed <input type="radio"/> Off <input type="radio"/> One <input type="radio"/> Two <input type="radio"/> Three	Fan 1 (Inner): 2 Fan 2 (Outer): 3 Fan 3 (Outer): 3	Temp : 30 Humid: 33.6 Ammonia MQ137: 2126 voc MQ135: 2186 Alcohol MQ3 :3490	Temp : 30 Humid: 33.6 Ammonia MQ137: 1609 voc MQ135: 2489 Alcohol MQ3 : 3472 PH : 4.47	Ammonia MQ137: 604.5 voc MQ135: 1040.25 Alcohol MQ3 : 1534
Submit		Cluster : 3	Cluster : 2	

Figure 4, Display the values of monitoring and control

During a very perilous circumstance at Cluster 4, a text message is dispatched and an alert is triggered within the store, prompting the pullers to operate at their utmost speed. Figure 5(a), (b) shows SMS alert if there is a significant danger in external and internal store.



(a)



(b)

Figure 5(a), (b), SMS alarm notification

VI. CONCLUSIONS

This paper discusses the design and implementation of a smart system for remote monitoring and control using remote terminal unit (ifan04, Esp32 with tagmata) without human intervention, Based on ML, the type of Unsupervised learning. An indoor safety shields that utilize IoT technology have been developed. A real-time system aims to save time and cost while protecting employees from hazard, diseases and fires, as well as protecting the environment from air pollution. In addition, system update, upgrade, and scalability is available and easy to be achieved for adding new sensors or robotics that may improve system functionality and protection since all system components are open source, code free and simple to interface with.

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