Lift (Elevator) Monitoring and Safety System Using ESP32

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Abstract— **In this report, an IoT, based lift surveillance and security system is introduced to improve elevator safety by observing both the external and internal conditions of the elevator in real, time. The innovative system combines various vital sensing devices that include thermometers, hygrometers, air quality sensors, smoke sensors, tilting switches, and audio pick, ups into one smart module that uses an ESP32 chip for efficient information gathering and analysis. An efficient MQTT messaging protocol allows the quick and reliable wireless data transfer between the embedded system and a Python, based GUI application. The GUI application supports the remote control of the motors to simulate lifting motions, warns users instantly about life, threatening situations, and presents real, time graphical representations of the data acquired from the sensors. The energy held in the rechargeable lithium; ion battery allows the system to work continuously even in the absence of electricity. The experiment has confirmed that the proposed remote monitoring method guarantees the accuracy of data, fast data transfer, and effective detection of threats. Based on the proof, this approach is a low, cost solution that is highly flexible in accommodating different sizes of buildings, especially for small office spaces and apartment buildings.**

Index Terms— **Smart IoT Systems, Elevator Safety Management, Lift Condition Monitoring, ESP32 Controller, Integrated Sensor Network, MQTT Communication Protocol, Live Data Monitoring, Gas Leakage Detection, Fire Hazard Detection, Tilt and Motion Detection, Audio Level Monitoring, Python-Based User Interface, Automated Motor Control**

I. INTRODUCTION

Therefore, there is a huge demand for a small, low-cost, and energy-efficient IoT-based elevator monitoring system. The system should be designed with multiple sensors for safety, strong wireless communication, and real-time information. But despite the many advances in the development of elevators, accidents still happen in some areas. These accidents happen because there is no early problem detection, there is no real-time monitoring, and the evaluation of the elevators is done only on a regular schedule and not all the time.

Most conventional elevators have mechanical safety systems such as overload protection, emergency brakes, door locks, and speed governors.

These assist in the promotion of safe elevator operation, but they lack real-time monitoring of the environment and the status of the elevator. Issues such as high temperatures, gas leaks, fires, unusual vibrations, and unusual sounds are not detected until they become major issues. Maintenance is performed only when the elevator malfunctions or becomes a hazard, allowing the system to react to the problem after it has occurred, not before.

The Internet of Things (IoT) has transformed dramatically the way elevator safety and monitoring are conducted. IoT allows the incorporation of smart sensors, computers, and wireless communication into elevator systems, enabling the data and changes to be constantly and instantly monitored. In such systems, sensors measure temperature, humidity, gas, fire, vibration, tilt, and noise levels. These sensors collect live data which can be observed, analyzed or even sent to a control center for issuing alerts. Studies have shown that IoT, based systems, by offering continuous monitoring of elevators rather than periodic checks, can identify problems at an early stage, thus lowering maintenance costs and increasing the reliability of elevators.

Some of the recent developments in smart elevator surveillance systems include monitoring the environment and identifying mechanical issues.

Smart elevator surveillance systems employ the use of advanced sensors to identify potential hazards such as smoke, fire, toxic gas, and faulty machinery. Through the real-time analysis of data from the sensors, the monitoring systems are able to identify potential hazards early and alert the maintenance team or the building administrators instantly. Research has shown that smart IoT systems have the ability to identify unusual patterns and predict failures before they become major issues or cause the elevator to malfunction.

These predictive features signal a paradigm change in the way maintenance of old equipment has been traditionally done (reactive maintenance), towards new data, driven approaches. Apart from forecasting functionalities, the real, time smart diagnosis is also a significant focus area for research concerning elevator safety.

These types of systems use sensor data to continuously assess the performance of the elevator. They can detect if the elevator is operating abnormally, e.g., if there is too much vibration, the motor is making an unusual sound or if there is some sort of noise. Real, time monitoring systems have been developed and utilized in large, scale elevator systems, achieving high levels of efficiency and maintenance issue identification among other benefits. Nevertheless, most of these systems incorporate complex infrastructures, cloud computing, and high, performance servers, thus being expensive and difficult to deploy in smaller buildings like residences or schools.

Wireless technology is a significant element in the real, time monitoring of elevators.

IoT, based systems generally use wireless technology to send data from the computer inside the elevator to a remote monitoring system. These smart systems have been shown to have faster response times, more central control, and better trouble awareness than traditional systems.

However, most present, day systems are greatly reliant on cloud technology, which can sometimes lead to problems such as slow internet speed, security issues, increased costs, and lack of reliability when there is no internet. In highly essential sectors such as elevator monitoring, even a small delay in communication can make the system less effective.

The expense and intricacy of smart monitoring systems at present are still preventing people from using them. Today's systems are very expensive regarding infrastructure, software, and communication. They are not really suitable for sectors such as residential areas, schools, and small businesses that need to be both affordable and easy to use. Currently, systems are mostly geared towards mechanical parts and do not take into account environmental factors such as gas leaks, fire detection, and temperature inside the elevator, which are very important for safety. Hence, there is a massive demand for a small, low-cost, and energy-efficient IoT-based elevator monitoring system.

The system should be designed with multiple sensors for safety, wireless communication, and real-time information. The system should be able to monitor and detect possible dangers beforehand and alert users immediately without the need for complicated cloud settings. With the aid of smart sensing, processing, and simple communication, the next generation of smart elevators will greatly improve the safety of passengers, decrease maintenance costs, and make the entire system more reliable.

II. NEED FOR THE SYSTEM

Right. The development of smart building technology has resulted in many research studies on the intelligent monitoring and safety system of elevators. The conventional elevator system needs periodic observation and safety systems, which are insufficient to identify potential problems and dangerous situations. To address these problems, researchers have been employing IoT technology, wireless sensors, and smart data analysis technology for elevator monitoring systems. This part covers the main research articles about safety systems of elevators based on IoT technology, fault identification, smart monitoring systems, and early warning systems. The initial research study on the safety system of elevators employed simple sensors with controllers to monitor the elevator system in real-time. The IoT technology-based elevator system demonstrated the feasibility of remote monitoring by transmitting sensor data to a central location for analysis and observation. Chen et al. presented an intelligent elevator system based on IoT technology, where sensors were employed to monitor the elevator system and transmit data wirelessly for observation. However, their system employed cloud systems, which made it less feasible and costly.

However, due to the increasing requirement for problem prediction and fault identification, scientists began employing real-time smart monitoring and diagnosis techniques.

Zhang et al. proposed a real-time smart monitoring and diagnosis system based on sensors and data analysis for abnormal operation identification. The system continuously monitored vibration and performance variables for early identification of mechanical problems. Although the system was highly effective in fault identification, it required high-performance computers and was suitable for large-scale elevator systems but not for small-scale systems.

More recent research works employed early warning systems based on IoT technology. Li et al. proposed a monitoring and early warning system based on IoT technology, which continuously checked the sensors for any indication of problems. The system immediately notified the user of problems, which helped in maintenance and prevented unexpected failures. The system enhanced safety and maintenance, but it required advanced data analysis software and high-speed internet.

Many recent studies have focused on monitoring elevators without changing the current hardware. Chen et al. came up with a non, intrusive method that employs the NB, IoT technology for remote monitoring of traction elevators. The system scrutinized the operations of the elevator thus allowing remote monitoring and long, distance communication capabilities. However, it was only suitable for commercial buildings and therefore could not be used in residential buildings.

Environmental safety has become a significant issue as a result of various incidents such as fires, gas leaks, and air pollution in elevators. Sun et al. came up with a brilliant idea of an intelligent elevator system that could keep track of energy consumed and the running of the elevator cabin. But, the system, despite its abilities, smartness, and efficiency, overlooked general safety measures, especially those regarding gas and fire, which are the most important for the protection of the users.Recently, there has been a growing emphasis on the fact that elevators should be monitored without changing the existing hardware. Chen et al. came up with a non, intrusive method that incorporates NB, IoT technology to enable remote monitoring of traction elevators. The system evaluated elevator operations and thus allowed remote monitoring and long, distance communications. It was a good solution for large buildings but it turned out to be ineffective in single, family houses.

One major issue is maintaining a safe environment at the same time. Recently there have been incidents of elevator air quality, gas leaks, and fire. Sun et al. carefully designed an intelligent elevator system to achieve energy, saving through regulation of the temperature and working condition of the elevator cabin. Even though the system showed a good result and high performance, it ignored important safety concerns that are necessary for passenger protection, such as gas and fire safety.

Currently, researches have been conducted on comprehensive fault monitoring and early warning systems that incorporate a variety of different sensors and smart devices. Zhou et al. created a system that employed multiple sensors to assess elevator components and the environment. The system was complicated and costly to install, but it allowed for remote monitoring and promptly detected problems. already many solutions are developed, still there is more gaps. many more solutions are based on cloud platforms and server, which makes them expensive and more complex to implement. Moreover, instead of concentrating on the environmental aspects of fire danger, gas emission, or air pollution, these solutions are more concerned with mechanical aspects.

Most elevator monitoring systems are designed for large business buildings and big companies, not for residential, educational, or small business needs. The reliance on costly, large, and not locally monitored systems shows a significant research gap in smart elevator safety.

There is a requirement for a cost-effective, multi-sensor, and locally monitored environmental hazard safety solution for elevators that can be based on the IoT. The solution should enable real-time communication, intelligent notifications, and distant accessibility without the complexities associated with cloud computing. The proposed solution will assist in safeguarding people, enabling early warnings for issues, and maintaining the solution cost-effective and user-friendly for small to medium-sized buildings.

III. LITERATURE REVIEW

The advancement of Internet of Things (IoT) technologies has significantly transformed elevator monitoring and safety systems by enabling real-time data collection, analysis, and remote control. Traditional elevator systems rely primarily on periodic maintenance and mechanical safety mechanisms such as emergency brakes, overload protection, and door locks. However, these systems lack continuous monitoring capabilities and fail to detect environmental hazards like gas leaks, fire, abnormal vibrations, and temperature fluctuations in real time.

Early research focused on integrating basic sensors with microcontrollers to enable remote monitoring of elevator conditions. For instance, IoT-based systems proposed by researchers such as Chen et al. demonstrated the feasibility of transmitting sensor data to centralized systems for analysis. However, these systems heavily relied on cloud infrastructure, resulting in increased cost, latency, and dependency on stable internet connectivity.

Subsequent studies introduced real-time fault detection and predictive maintenance models. Zhang et al. developed intelligent monitoring systems capable of analyzing vibration and operational parameters to detect anomalies. While effective in identifying mechanical faults, these systems required high computational resources and were primarily designed for large-scale commercial applications.

Recent developments emphasize early warning systems and multi-sensor integration. Li et al. proposed IoT-enabled monitoring systems that continuously analyze sensor data and generate real-time alerts for potential failures. Similarly, non-intrusive monitoring approaches using NB-IoT technology have been explored to enable remote diagnostics without modifying existing elevator infrastructure. However, such systems are often limited to industrial or commercial environments and are not cost-effective for smaller installations.

Environmental safety has also gained attention in recent studies. Systems developed by Sun et al. focus on energy efficiency and operational optimization but often overlook critical safety parameters such as gas leakage and fire detection. More comprehensive solutions, such as those proposed by Zhou et al., integrate multiple sensors for both mechanical and environmental monitoring. Despite their effectiveness, these systems are complex, expensive, and difficult to deploy in small-scale settings.

A key limitation identified across existing research is the high dependency on cloud-based architectures, which introduces challenges such as latency, security risks, and increased operational costs. Additionally, most systems prioritize mechanical fault detection over environmental hazard monitoring, leaving a significant gap in holistic safety solutions.

Therefore, there is a clear need for a cost-effective, energy-efficient, and scalable IoT-based elevator monitoring system that integrates multi-sensor data, supports real-time communication, and operates with minimal reliance on cloud infrastructure. Such a system would be particularly beneficial for residential buildings, educational institutions, and small commercial setups, where affordability and simplicity are critical requirements.

IV. METHODOLOGY

The system architecture for monitoring and ensuring safety in lifts with IoT technology is structured as a hierarchy that combines environmental sensing, processing, communication, visualization, and motor control. The core aim of such a system is to provide safety monitoring, hazard warning, and remote-control facility for the lift leveraging cost, effective and energy, efficient hardware. The system comprises six layers as illustrated in the diagram of the system.

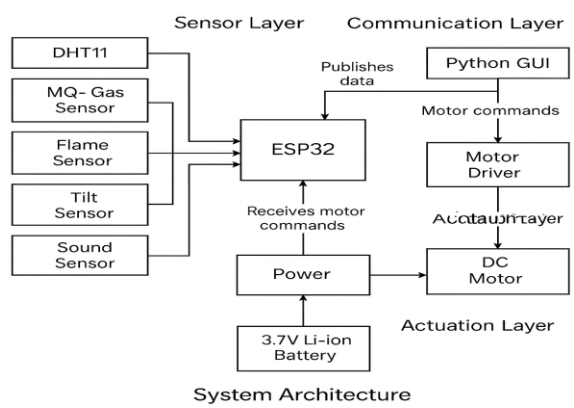

Figure. 1. System Architecture Diagram

A. Environmental Sensor Data Collection Layer

The bottom layer is consistent data gathering on environmental and security conditions by a set of sensors installed in the lift cabin.

The sensors employed are:

a. DHT11 temperature and humidity sensor

b. MQ, series gas sensor for detection of harmful gases such as LPG and methane

c. Infrared flame sensor for fire detection d. SW, 520D tilt sensor for detection of unusual tilting or movemente. LM393 sound sensor for detection of unusual sound levels

The DHT11 sensor reports on the changes of temperature and humidity which can be used to identify overheating or presence of moisture.

The gas sensor gives information on flammable or harmful gases such as methane from nearby pipes or during maintenance. The flame sensor gives information on fire by sensing infrared radiation. The tilt sensor gives information on unusual vibrations or tilting, which may show that there is a problem with the structure or functionality of the lift.

The sound sensor gives information on unusual sound levels, which may show that the motor is faulty, the cables are damaged, or there is mechanical stress. Each sensor gives an analog or digital signal depending on the conditions.

The signals are transmitted to the ESP32 microcontroller using designated ports to enable the microcontroller to read the signals.

B. Processing and Control Layer

The microcontroller ESP32 is the heart of the system. It gets the raw data from the sensors, processes the data to translate the signals into actual values, and performs the safety checks. The ESP32 microcontroller is chosen for this project due to its WiFi connectivity capability, dual cores which can be run simultaneously, ultra, low power consumption and has a number of ports to connect other components which makes it the best option for IoT projects that involve multiple sensors [12].

Also, the ESP32 device periodically performs reading of sensor data and checks them. At first, the system verifies the sensor values. Then, it compares them with the safe limits. If any value is higher than the safe limit, the controller turns on the alarm and gets a message ready to send.

The ESP32 identifies the level of danger in the scenario and the alarm to sound. The controller also waits for signals from a distant interface. After the ESP32 gets signals like UP, DOWN, or STOP, it decides the right control logic and drives a motor driver which in turn controls the lift's motion.

C. Communication and Data Transmission Layer

This layer enables the system to transmit data and receive commands from the microcontroller to the monitoring interface. The ESP32 transmits sensor data and receives motor commands through WiFi using the best IoT messaging protocol. The publish-subscribe model enables fast and reliable data transmission, which enables real-time safety monitoring.

Sensor data including temperature, humidity, gas concentration, fire detection, sound levels, and tilt position are transmitted periodically to designated channels. The monitoring interface listens to the channels and receives real-time updates. On the other hand, commands from the interface are transmitted to the ESP32 through designated channels. This enables real-time monitoring and command sending from a distance [13].

The communication system does not rely on resource-intensive cloud computing systems, which makes it faster, cheaper, and reliable even when there are network failures.

D. Application and Visualization Layer

This layer is developed using a Python, based GUI, which serves as the main channel for interaction between the user and the system.

The GUI presents real, time data from all the sensors in a neat and well, readable manner. It shows temperature, humidity, gas concentration, fire detection status, sound, and tilt status.

Different colors signify the system status:

a. Green indicates that everything is going well

b. Yellow indicates a warning

c. Red indicates an immediate danger

If the system finds any dangerous situations, the GUI automatically displays warnings.

All abnormal situations are stored for future analysis and debugging [14].

The GUI has buttons to control the lift from far away. When a button is pressed, the ESP32 does the action.

E. Actuation and Motor Control Layer

The simulation of the motion of the lift is done by a DC motor and a motor driver. The motor driver connects the ESP32 to the motor, which allows it to rotate in both directions at different speeds.

The algorithm of motor control given below

a. UP Command: The motor turns clockwise, simulating the upward motion

b. DOWN Command: The motor turns counter-clockwise, simulating the downward motion

c. STOP Command: The motor instantly stops

This design enables a realistic simulation of the functionality of the lift system and verifies that the system is capable of executing remote commands successfully.

F. Power Management and Backup Layer

The system relies on a 3.7V rechargeable lithium, ion battery that includes a voltage regulator. The regulator continually powers both the ESP32 module and the sensors. Power management system guarantees system operation in case of main power failure. This is the key point for safety preservation.

V. HARDWARE SPECIFICATION

The modular and layered architecture based on IoT for monitoring and safety of the lift is a combination of hardware and software modules. The system architecture is capable of handling environmental sensing, embedded processing, wireless communication, real, time visualization, and motor control. The proposed system is capable of delivering safety monitoring 24/7, detecting hazards early, and allowing the lift to be checked from a far, off place.

Different sensors are connected to the microcontroller that receives and processes the data and then drives the display interface and the motor by the block diagram which describes the whole process of operation.

The four main parts of the system are: a sensor interface unit, an embedded control unit, a display and communication interface, and a motor control and actuation unit.

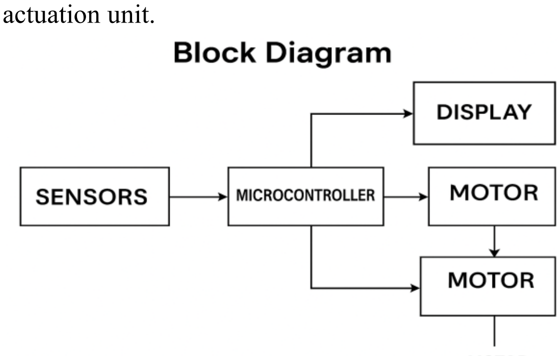

Fig. 2. Block Diagram

A. Sensor Interface Unit

The sensor interface unit is the input unit of the system, and it is responsible for the continuous monitoring of the environment and activities taking place within the lift cabin.

The system employs the use of various sensors, such as temperature and humidity sensors, gas sensors, flame sensors, tilt sensors, and sound sensors.

The sensors are fitted inside the lift model to monitor the critical safety features. Sensors output analog or digital signals, depending on the situation.

Temperature and humidity sensor is a vital part of the indoor environment monitoring system that helps prevent overheating and the build, up of excessive moisture. The gas sensor is the component that identifies the presence of hazardous gases such as LPG and methane which pose a significant risk in a non, ventilated area. The flame sensor detects a fire by sensing the infrared ray emitted by the flames. The tilt sensor can detect unusual vibrations or sudden motions of the structure which can be an indication of a mechanical or structural failure. The sound sensor is used to pick up abnormal sounds that could result from motor bearings with lack of lubrication, cable friction, or misaligned pulleys.

The sensors send their signals to the microcontroller through GPIO pins dedicated to each sensor. Various signal processing and noise removal methods are applied to achieve smooth and accurate data. Using cheap and easily available sensors can be a great way to keep the system cost down while still ensuring a high level of safety [15], [16].

B. Embedded Control Unit

An embedded control unit contains an ESP32 microcontroller, which acts as a CPU and decision, making unit of the system.

The reason for choosing the ESP32 microcontroller lies in its WiFi capabilities, dual, core processor, low power consumption, and high processing power, which together make it the best choice for multi, sensor IoT applications [17].

The microcontroller is capable of carrying out the following major functions:

1.Constantly obtaining data from sensors

2. Signal processing and calibration

3. Detection of hazards based on threshold levels

4. Real-time communication with the display interface

5. Motor control and actuation

At regular time intervals, the ESP32 microcontroller acquires the raw data from the sensors and after cleaning it, generates secondary data of temperature in C, humidity in %, gas concentration in ppm, and fire detection status (binary) It then compares these data with the safety threshold values. In case any value goes beyond the safety limit, the controller generates an internal warning and an emergency message would be dispatched. The control software is written in Arduino IDE for ESP32. The software architecture employs a real, time task scheduling method to deal with the simultaneous execution of tasks like sensor data acquisition, communication, and motor control. Additionally, the controller keeps track of the commands coming from the user interface and reacts to the motor commands accordingly.

C. Display and Communication Interface

The display and communication interface serves as a medium of communication between humans and the system.

The interface is made of a python, based graphical user interface (GUI) that visually shows the real, time data obtained from the sensors as well as the system's status. The GUI is linked to the microcontroller's data channels and outputs the sensor data in a human, readable and understandable format.

The display visually communicates:

temperature and humidity levelsgas concentration flame detection statustilt and vibration statussound intensityThe system's condition is visually communicated through color, coded lights. A green light signals that the system is safe, a yellow light is a warning and red light indicates system is in danger. GUI warns visually and audibly if the system becomes unsafe. All abnormal events are recorded, giving assistance in after, event analysis and debugging.

The communication interface allows the microcontroller and the GUI to exchange data in both directions. The sensor data is always being transmitted from the microcontroller to the display, at the same time motor control commands are sent from the GUI to the microcontroller.

D. Motor Control and Actuation Unit

The motor control and actuation unit is responsible for the physical movement of the lift. A DC motor is used to perform the movement and it is connected to the motor driver module.

The motor driver module is the interface between the microcontroller that operates at low power and the motor that requires high power, so it efficiently and safely transmits power.

The motor control logic has three basic commands:

UP Command: The Motor will rotate in the clockwise direction, thus simulating the hoisting action. DOWN Command: The Motor rotates counter, clockwise to simulate the lowering STOP Command: The Motor is stopped immediately

Once the instruction is received, the microcontroller activates the motor driver pins and starts the motor.

The motor driver module has the features of current amplification, voltage regulation, overcurrent, and short circuit protection. This is done to ensure safe motor operation and the prevention of electrical damage to the electronic components.

Right after the command, the motor moves at a very high speed, which is a vivid indication that the system is capable of carrying out real, time actuation and emergency stop functions. Motor actuation is going to be a basic attribute of future smart elevator systems, where intelligent surveillance could be combined with mechanized reactions to yield higher safety and efficiency.

E. Power Supply and Backup Unit

The power management system is responsible for providing a constant voltage to all components of the system. The system uses a 3.7V rechargeable lithium-ion battery and a voltage regulation module to provide the required power to the microcontroller, sensors, and motor driver. The battery backup system plays a crucial role in the safety of elevators as it is mainly there to make sure the system carries on working in case of electricity failure. Power status monitoring and sending alert notifications if there is a power outage can be measures through which accidents are avoided and the safety of passengers is guaranteed. Since the ESP32 module is low, power, it guarantees a longer system operation time when the battery is fully charged, thus making it ideal for use in emergencies.

Battery-powered IoT systems are widely used in critical safety applications because they are reliable and do not rely on the power supply of the building [20].

F. Overall System Operation

The overall system works in the following way:

a. The sensors are constantly observing the environment and safety conditions inside the elevator cabin

b. The data from the sensors is sent to the microcontroller for processing

c. The microcontroller compares the data from the sensors with the safety limits defined

d. The processed data is sent to the display screen

e. The user interface displays real-time data and alerts in case of dangerous conditions

f. Through the interface, the user supplies control commands to operate the motor g. Based on the inputs, the microcontroller commands the motor to run accordingly h. A battery backup system should ensure that the system keeps working even without a power supply

VI. RESULT AND ANALYSIS

An IoT, based lift monitoring and safety system was put together and introduced by the authors. The system comprises a multi, sensor module with wireless communication, real, time data display, and motor control features. The experimental set, up was an ESP32 microcontroller connected with temperature and humidity, gas, flame, tilt, and sound sensors, a DC motor, which is a motor driver, a Python, based user interface, and a lithium, ion battery as a backup power source. The system was deployed and made use of under different environmental and operational conditions to assess its real, time monitoring, precise detection of hazards, efficient communication, and remote control. The assessment was by looking at four main facets: sensor performance, communication efficiency, hazard detection effectiveness, and system response time. Findings indicate that the system can monitor, detect hazards early, and provide real, time remote control.

A. Performance of the Sensors and Environmental Monitoring

Initially, the sensors were tested as the first step of the evaluation process.

For testing, the DHT11 temperature and humidity sensor was locally heated a closed room with the help of a heating element to increase the temperature. The readings shown on the Python GUI were checked by a reference thermometer. The temperature measurements were within two degrees of Celsius on either side. This level of accuracy is a good match with the precision of DHT11 sensors, which have a tolerable variation of 2C. Besides, the readings from the humidity sensor were dependable and demonstrated the fluctuation in the surroundings over time. MQ, series gas sensor was checked by the method of exposing it to LPG. The sensor indicated a fast rise in output voltage when the gas level exceeded the limit. The system responded to a gas leak in 2 to 3 seconds.

This is very crucial to prevent situations of grave danger in the closed, up places of elevators, as illustrated in the previous research studies on safety systems. The flame sensor was tested by the method of exposing it to a controlled flame source.

The infrared sensor reacted instantly when the flame was in its vicinity, and the ESP32 after receiving the signal from the sensor forwarded it to the GUI, which showed a fire alert in less than one second. Early detection of fire is crucial for the safety of elevators and the technology has been utilized in diverse safety systems for industrial applications.

The SW, 520D tilt sensor was tested by the method of controlled vibrations and the tilting of the lift model. As soon as the limit was reached, the sensor instantly reacted to the abnormal movements and vibrations by sending out a tilt alert. Vibration detection has been a widely employed safety measure for mechanisms, especially in the use of safety systems.

B. Real, Time Communication and Data Transmission

Communication efficiency within the system was validated by confirming that the data was actually transferred from the ESP32 to the Python GUI. The ESP32 was incessantly sending sensor data, and the GUI was receiving and showing the data. The average time of data transfer was less than 200 milliseconds under normal WiFi conditions.

The rapid response has made it possible for the data to be almost instantaneously visualized on the GUI. Real, time monitoring enables the operators to keep a constant check on the elevator's condition and also be able to react immediately to any problem. The communication channel with feedback in the motor control experiment was demonstrated to be a very reliable one. The GUI commands were quickly received by ESP32 without any data loss or delay.

The system was able to guarantee reliable communication even for an extended time period and, therefore, it was confirmed that lightweight IoT communication is adequate for critical safety applications.

C. Hazard Detection and Alert Generation

The system's capability to detect hazards was also assessed by simulating various emergency scenarios. The functionalities of the sensors were checked individually and collectively to determine the capability to detect multiple hazards. The GUI immediately displayed a red warning notification with a warning sound when the gas level rose above the safe limit. A flame hazard indicated a high, priority fire warning message. High temperatures indicated an overheating warning message. Tilt and vibration warnings indicated structural issues, while unusual sounds indicated possible mechanical issues.

The system managed to detect several hazards simultaneously and display separate warning messages for each of the dangers. The capacity to detect several hazards at the same time is more thorough and offers greater safety protection than normal systems that only concentrate on the mechanical parts. The alert system assigned higher priority to more critical hazards such as fire and gas leaks compared to the less critical ones like sound and vibration. This facilitates faster decision, making, which is in line with the principles of modern safety design.

D. Motor Control and Actuation

A DC motor was used for testing the motor control system where it was assumed to be the elevator elevator.

The commands were sent to the motor driver from the ESP32 which controlled the motor in the following way:

a. Up command clockwise motion

b. Down command counter, clockwise motion

c. Stop command instant stop

The motor immediately reacted to all commands from the GUI.

It was not possible to detect the delay between the command sending time and the motor starting to move time.

The stop command was implemented properly to stop the motor even when it was running, thus, the system has an emergency stop function.

The instant control of the motor is an indication that the system is capable of elevator control at a distance and also how the elevator control system of the future can be coupled with smart monitoring and automatic responses.

E. Power Backup and System Reliability

One of the ways the power system was challenged was when the main power source was turned off while the system was already running.

It was the 3.7V lithium, ion battery that stepped in and allowed the system to continue running. Even on battery power, the sensor monitoring, communication, and notifications were still functioning properly. During a power failure, it is very important that the ESP32 can be powered by a battery for a long time and this was demonstrated.

IoT systems like this one that rely on battery power have been demonstrated to be a very efficient way to increase the reliability of such devices during emergency situations.

F. Overall System Performance Analysis

The tests show that the proposed solution can perform the following tasks successfully:

a. Real, time monitoring of the environment and safety conditionsb. Reliable hazard detection and warningc. Fast wireless communication with low latencyd. Real, time remote control of motorse. Continuous operation with battery supportThe proposed system basically integrates data collection from multi, sensors, processing, wireless communication, visualization, and actuation into one system, thus resulting in a complete smart elevator security system.

In terms of situation awareness, response speed, and system reliability, the proposed system is more advantageous than the conventional ways of elevator safety.

Discussion

The results show that the IoT lift safety system is able to offer full safety coverage with the help of low-cost components and simple communication methods.

It is also able to perform well in different environments, making it a good choice to be implemented in residential, educational, and small-scale commercial institutions.

The results are consistent with the latest trends in smart building safety systems and support the effectiveness

of using multiple sensors in IoT systems for real-time danger detection and remote monitoring [15]– [22].
The proposed system architecture is highly modular and can be easily reconfigured to include advanced features such as cloud analysis, mobile interaction, AI, based maintenance, etc. in the future.

VII. CONCLUSION AND FUTURE SCOPE

The paper essentially put forward a new framework of elevator security monitoring and safety assurance which basically relied on the Internet of Things (IoT) technology. The system was basically meant to make the passengers safer, provide a reliable means of elevator services, and allow for real, time monitoring of the system easily. The system integrates several safety and environmental sensors, an ESP32 microcontroller, wireless communication, real, time data display, and motor control into one smart and intelligent monitoring system.
The system basically provides a cost, effective and feasible solution to smart elevator safety by means of continuous sensing, embedded processing, efficient wireless communication, and battery backup.
The experimental findings indicate that the system is capable of monitoring the temperature, humidity, gas, fire, tilt movement, and noise in the elevator continuously.
The use of multiple sensors offers the capability to monitor several potentially dangerous situations at the same time. The early warning of signs of fire, gas leakage, unusual vibration, high noise levels, and overheating prevents these situations from becoming potential hazards to safety. This is more effective than the conventional safety system, which responds only after the occurrence of a situation.

As far as incorporating a variety of sensors and handling their data in real, time, ESP32 microcontroller did very well.
Thanks to wireless communication, low power consumption, and high processing power, the system could efficiently collect data, make correct decisions, and communicate with the monitoring interface. Lightweight publish, subscribe communication system enabled fast data transmission which made it possible for the sensor data to be displayed on the screen almost instantly. Thanks to this real, time response, the operator, maintenance staff, and building authorities can be informed of the situation at any time.

The system comprises a Python, based graphical user interface (GUI) that acts as a monitor and control tool for the system.
Whenever the sensors detect hazardous conditions, the interface automatically sends out warnings and presents sensor data in a very clear way. Usage of event logs and color, coded warning signs helps to increase the system's user, friendliness and makes fault detection and diagnosis easier. Besides monitoring, the interface also facilitates remote, control of the elevator motor which, therefore, demonstrates the use of safety systems for automated responses to real, world situations.
The system's actuator component verified the system's capability to process live control commands by simulating an elevator's motion through

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