IoT-Based Anti-Theft Flooring System

Jignesh Borse[1], Vedant Magare[2], Eishwari Bhapkar[3], Nilesh N. Thorat[4]
[1,2,3]*Student, MIT School of Computing MIT Art Design & Technology University Pune, India*
[4]*Assistant Professor, MIT School of Computing MIT Art Design & Technology University Pune, India*

***Abstract*—The IoT-Based Anti-Theft Flooring System provides an additional layer of security by detecting footsteps and unusual pressure using piezoelectric sensors placed beneath floor tiles. The signals are converted into digital values using an MCP3008 ADC and processed by a Raspberry Pi 4 to identify suspicious activity. When unusual pressure is detected, a buzzer is activated, and the event is stored in Supabase for monitoring through a web-based dashboard. The system offers a cost-effective, hidden, and privacy-friendly security solution for protecting homes and other valuable areas.**

***Index Terms*—component, formatting, style, styling, insert**

I. INTRODUCTION

Security has become an important concern in residential, commercial, and industrial environments. Places such as homes, banks, museums, laboratories, and storage facilities require systems that can identify unauthorized entry and protect valuable objects. Traditional security solutions include CCTV cameras, infrared sensors, motion detectors, and door alarms. Although these technologies are useful, they may have certain limitations. Cameras require proper placement and monitoring, while motion detectors may not identify every type of movement. Some systems can also be avoided if an intruder finds a way around their detection area. To address these limitations, this project introduces an IoT-based flooring system that uses the floor itself as a detection surface. Piezoelectric sensors are installed beneath floor tiles to sense pressure and vibrations caused by footsteps or other physical activity. The generated signals are processed by a Raspberry Pi 4 through an MCP3008 ADC. When the detected pressure crosses a predefined threshold, the system treats the event as potentially suspicious. It activates a buzzer and sends the event information to a Supabase cloud database. The information is then made available through a web-based dashboard. The proposed solution acts as an additional security layer and can be used along with existing security arrangements.

II. EASE OF USE

The IoT-Based Anti-Theft Flooring System is designed to provide simple and convenient security monitoring with minimum user interaction. Once the hardware components are installed and configured, the system can continuously monitor the selected floor area without requiring the user to operate it manually. The use of piezoelectric sensors beneath the floor tiles makes the detection process hidden and does not require users to carry or operate any additional device. The Raspberry Pi 4 automatically processes the sensor readings and activates the buzzer whenever unusual pressure is detected. The web-based dashboard provides a simple way to monitor system activity. Users can check the current status of the system and view previously recorded alerts through the dashboard. Supabase stores the event information, making it easier to access the security records when required. The system uses automatic detection, local alarm generation, and cloud-based event storage to reduce the need for continuous manual monitoring. It's simple working process makes it suitable for home owners, security personnel, and users who need an additional security solution without operating complex surveillance equipment.

III. PROBLEM STATEMENT

Most conventional security systems depend on visible devices such as cameras, motion sensors, and door alarms. These systems may have limitations in detecting movement in areas that are not covered by their sensors or cameras. There is a need for a system that can detect physical activity directly through the

floor surface. Such a solution should identify unusual pressure, generate an immediate local alert, and make event information available to authorized users remotely. The proposed system addresses this requirement through pressure-sensitive floor tiles connected to an IoT-based monitoring platform.

IV. OBJECTIVE

The main objective of the IoT-Based Anti-Theft Flooring System is to develop a smart security solution that can identify unusual pressure or movement on floor tiles and generate alerts whenever suspicious activity is detected. The system is designed to provide an additional layer of protection in areas where valuable items, equipment, or important resources are stored.

The major objectives of the proposed system are:

1. Footstep and Pressure Detection: To use piezoelectric sensors placed beneath floor tiles to detect pressure and vibrations caused by footsteps or other physical activities.
2. Real-Time Data Processing: To collect analog signals from the sensors and convert them into digital values using the MCP3008 ADC for further processing by the Raspberry Pi 4.
3. Suspicious Activity Identification: To compare the processed sensor readings with predefined threshold values and identify unusual pressure conditions.
4. Instant Alert Generation: To activate a buzzer whenever the sensor reading crosses the configured threshold, indicating a possible security event.
5. Cloud-Based Data Storage: To store detected events with timestamps in the Supabase database for future reference and monitoring.
6. Web-Based Monitoring: To provide a dashboard through which users can view the current system status and previously recorded alerts.

V. SCOPE OF THE PROJECT

The scope of this project is to design and implement an IoT-based intrusion detection system using pressure-sensitive floor tiles. The system focuses on detecting physical activity directly through the floor instead of depending only on cameras, door sensors, or conventional motion detectors. Piezoelectric sensors are installed beneath selected floor tiles to identify pressure changes. The signals generated by these sensors are processed by a Raspberry Pi 4 through an MCP3008 analog-to-digital converter. Based on predefined threshold values, the system identifies unusual pressure readings and activates an alarm. The project also includes cloud integration using Supabase, which stores event information and allows users to monitor alerts through a web-based dashboard. The system can be considered for use in homes, offices, storage rooms, laboratories, and other restricted areas. The current implementation focuses on a working prototype with sensor monitoring, local alert generation, cloud event logging, and dashboard-based monitoring. Expansion to multiple tiles, mobile notifications, and advanced activity classification can be considered in future development.

VI. EXISTING SYSTEM AND PROPOSED SYSTEM

A. Existing System

Traditional security systems commonly use CCTV cameras, infrared motion sensors, door alarms, RFID systems, and manual security monitoring. These technologies are useful for monitoring buildings and detecting unauthorized entry. However, each method has certain limitations. CCTV cameras require proper placement and may have blind spots. They also capture visual information, which can create privacy concerns in certain locations. Motion sensors generally detect movement within a particular sensing range and may not identify every type of physical activity. Door and window alarms mainly detect opening or unauthorized access through specific entry points. Manual security monitoring depends on the continuous attention of security personnel. Human fatigue, limited coverage, and delayed response can affect the overall monitoring process. Some conventional systems also provide limited cloud-based monitoring, making it difficult for users to check security events remotely.

B. Proposed System

The proposed IoT-Based Anti-Theft Flooring System introduces a floor-based method of detecting suspicious physical activity. Piezoelectric sensors are installed beneath floor tiles so that pressure or vibrations can be detected when a person steps on the

monitored area. The analog output generated by the sensors is transferred to the MCP3008 ADC, which converts the signals into digital values. The Raspberry Pi 4 processes these values and compares them with predefined threshold levels. When the reading crosses the configured threshold, the system identifies it as a possible suspicious event and activates the buzzer. At the same time, event information is sent to the Supabase cloud database. The web dashboard displays the recorded alerts and current system status, allowing the user to monitor the system without continuously checking the hardware setup. This approach provides hidden floor-level monitoring and works as an additional security layer alongside existing security arrangements.

VII. SYSTEM ARCHITECTURE

The architecture of the proposed system consists of different functional components that work together to detect unusual pressure and generate security alerts. The complete process begins with sensor-based pressure detection and ends with local alarm activation and cloud-based event monitoring.

A. Sensing Layer The sensing layer consists of piezoelectric sensors placed beneath the floor tiles. These sensors generate electrical signals when mechanical pressure or vibration is applied to them. When a person steps on the monitored tile, the sensor produces an output that represents the applied physical activity.

B. Data Acquisition Layer The output generated by the piezoelectric sensors is analog in nature. Since the Raspberry Pi 4 requires digital input for processing, the MCP3008 Analog-to-Digital Converter is used. It converts the analog sensor signals into digital readings that can be received by the Raspberry Pi.

C. Processing Layer the Raspberry Pi 4 acts as the main processing unit of the system. A Python program continuously reads the digital values received from the ADC. These readings are compared with predefined threshold values to identify unusual pressure conditions. If the processed reading remains within the configured range, the system continues normal monitoring. If the reading crosses the threshold, the system treats it as a possible suspicious event and initiates the alert process.

D. Communication and Cloud Layer The system uses Supabase as its cloud backend for storing event information. When a suspicious event is detected, the Raspberry Pi sends the relevant event data to the cloud database. The stored information can be accessed later through the connected web dashboard.

E. Alert and User Interface Layer The alert layer includes a buzzer that provides a local warning when unusual pressure is detected. A web-based dashboard is also provided to display system activity and recorded alerts. This allows the user or security personnel to check the system status and review previous events.

VIII. HARDWARE AND SOFTWARE REQUIREMENTS

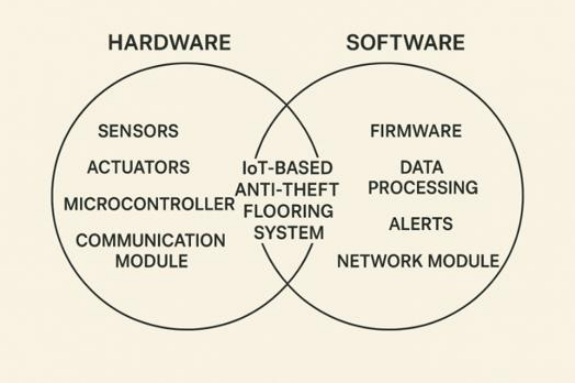
A. Hardware Requirements

1. Piezoelectric Sensors: These sensors are used to detect mechanical pressure and vibrations generated by footsteps or physical contact with the floor tiles. They convert mechanical stress into electrical signals and act as the primary sensing component.
2. Raspberry Pi 4: The Raspberry Pi 4 is used as the main processing unit. It receives digital readings from the ADC, executes the Python program, checks sensor values, controls the buzzer, and communicates with the cloud backend.
3. MCP3008 ADC: The MCP3008 is an analog-to-digital converter used to convert the analog output of the piezoelectric sensors into digital values. This enables the Raspberry Pi to process the sensor readings.
4. Buzzer: The buzzer is used to generate a local audio alert whenever the system detects a sensor reading above the configured threshold.
5. Floor Tiles and Connecting Components: Floor tiles provide the physical surface beneath which the sensors are installed. Connecting wires and supporting electronic components are used to establish the required hardware connections

B. Software Requirements

1. Python: Python is used to develop the program responsible for reading sensor values, processing the input, comparing readings with threshold values, and controlling the alert mechanism.

2. Supabase: Supabase is used as the cloud backend to store event information and timestamps. It supports the storage and retrieval of security-related records.
3. Web Dashboard: The dashboard provides a user interface for displaying the current system status and previously recorded events.
4. Raspberry Pi Operating System: The operating system provides the environment required to execute the Python program and communicate with connected hardware components.



IX . METHODOLOGY

The project follows the Waterfall Model as its development methodology. This model was selected because the project requirements were identified in advance and the development activities could be performed in a structured sequence.

The development process consists of the following stages:

1. Requirement Analysis: The first stage involved identifying the need for a floor-based security system and selecting the required hardware and software components. The major requirements included piezoelectric sensors, Raspberry Pi 4, MCP3008 ADC, buzzer, Python programming, Supabase, and a web dashboard.
2. System Design: In this stage, the overall architecture was planned. The placement of sensors beneath the tiles, connection between the ADC and Raspberry Pi, data processing flow, buzzer operation, and cloud communication were considered.
3. Hardware and Software Implementation: The hardware components were connected to form the sensing and processing unit. Python scripts were developed to collect sensor readings, process the values, and activate the buzzer when the configured threshold was crossed.
4. Cloud Integration: Supabase was connected to the system to store detected event information. A web dashboard was developed to display system activity and recorded alerts.
5. Testing and Verification: Individual components and the complete system were tested. Sensor readings, ADC conversion, buzzer activation, cloud data storage, and dashboard updates were checked to verify the working of the system.
6. Deployment: After implementation and testing, the working prototype was prepared for operation as an additional security monitoring system.

X. SOFTWARE REQUIREMENTS AND FUNCTIONALITY

The software component controls the complete data flow between the sensors, Raspberry Pi, buzzer, cloud database, and web dashboard.

The main functional requirements are:

- Sensor Data Capture: The system should continuously read pressure and vibration values generated by the piezoelectric sensors.
- Data Conversion: The MCP3008 ADC should convert analog sensor signals into digital values.
- Signal Processing: The Raspberry Pi should process the received values and compare them with predefined thresholds.
- Alert Triggering: The buzzer should be activated when the sensor reading crosses the configured threshold.
- Cloud Data Logging: The detected event information should be stored in Supabase with a timestamp.
- Dashboard Monitoring: The web dashboard should display the system status and recorded security alerts.

The system is also expected to provide consistent monitoring, a simple user interface, and reliable communication between its hardware and software components.

XI. RESULTS AND DISCUSSION

The developed prototype demonstrates the working of an IoT-based floor pressure monitoring system. The piezoelectric sensors are used to identify physical pressure, while the MCP3008 ADC converts the generated analog signals into digital readings for processing. The Raspberry Pi 4 successfully performs the threshold-based checking process. When the configured threshold is crossed, the buzzer is activated to provide a local warning. The system also sends event information to Supabase, where the records can be stored and accessed through the web dashboard. The testing process included checking the individual hardware components, verifying the connection between the sensor, ADC, and Raspberry Pi, and confirming communication between the Raspberry Pi and Supabase. Dashboard updates were also checked after generating a test event. The project report records that the system responded to detected events within one second during the reported testing. This demonstrates the feasibility of using the proposed arrangement for basic floor-level security monitoring. However, the system's performance can depend on sensor placement, calibration, floor material, and the selected threshold value.

XII. ADVANTAGES AND APPLICATIONS

A. Advantages

- Privacy-Friendly Monitoring: The system detects pressure through floor sensors and does not require continuous video recording for basic event detection.
- Hidden Installation: Sensors are placed beneath floor tiles, making the sensing arrangement less visible to people entering the monitored area.
- Real-Time Alert Generation: The buzzer provides a local warning when unusual pressure is detected.
- Cloud-Based Event Storage: Supabase stores event information, allowing users to review previously recorded alerts.
- Remote Monitoring: The web dashboard provides access to system activity without requiring the user to remain near the hardware setup.
- Expandable Design: Additional sensors and floor tiles can be considered to extend monitoring coverage.

B. Applications

- Smart Homes: The system can provide an additional security layer for selected rooms and areas where valuable belongings are stored.
- Banks and Storage Areas: It can be considered for monitoring restricted areas containing important documents, equipment, or valuable items.
- Museums and Galleries: Floor-based monitoring can support the protection of selected display and restricted areas.
- Laboratories: The system can help monitor access to areas containing sensitive instruments and equipment.
- Server Rooms: It can provide an additional method of detecting physical activity around important computing equipment.

XIII. LIMITATIONS AND FUTURE SCOPE

A. Limitations

- The current system has certain limitations that may affect its performance in different environments. Piezoelectric sensor sensitivity can vary depending on the installation method and floor material. Therefore, proper calibration is required to obtain suitable threshold values.
- The current prototype covers only the floor area where sensors have been installed. Monitoring a larger room or building would require additional sensors and an expanded hardware arrangement.
- The existing dashboard is designed for web-based monitoring, while a dedicated mobile application is not included in the current implementation. Also, threshold-based detection may identify unusual pressure without accurately distinguishing between normal footsteps, accidental impacts, and actual intrusion attempts.

B. Future Scope

The system can be improved through several additional features:

- Machine Learning-Based Classification: Machine learning techniques can be introduced to study different pressure patterns and improve the distinction between normal and unusual activity.
- Mobile Application Integration: A mobile application can be developed to provide users with security notifications and access to event history.

- Wireless Sensor Communication: Wireless communication can be introduced to connect multiple floor tiles and reduce complex wiring.
- Multi-Tile Monitoring: The system can be expanded to cover larger areas by installing additional sensors beneath multiple tiles.
- Camera-Based Verification: Camera integration can be considered for capturing images after a suspicious event, where privacy and deployment requirements permit.
- Additional Notification Methods: SMS, WhatsApp, or mobile push notifications can be integrated to improve alert delivery.

XIV. CONCLUSION

The IoT-Based Anti-Theft Flooring System presents a floor-based approach to security monitoring by using piezoelectric sensors to detect pressure and vibrations. The system combines sensor technology, analog-to-digital conversion, Raspberry Pi-based processing, and cloud connectivity to identify unusual pressure conditions and generate alerts. The MCP3008 ADC converts the analog signals into digital values, which are processed by the Raspberry Pi 4. When the configured threshold is crossed, the buzzer is activated and the event information is stored in Supabase. The web dashboard allows users to monitor system activity and review recorded alerts. The developed prototype demonstrates how IoT technology can be used to create an additional layer of security without depending entirely on conventional camera-based monitoring. Although improvements are required in sensor calibration, coverage, and activity classification, the proposed system provides a foundation for further development of smart and privacy-conscious security solutions.

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