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Anti-Theft Flooring System Using ESP32

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Abstract: Security systems play a vital role in protecting residential, commercial and institutional environments. Conventional security solutions such as CCTV cameras, magnetic door sensors and motion detectors mainly focus on entry points like doors and windows. However, these systems often fail to detect intruders once they enter the protected area or generate false alarms due to environmental disturbances, pets or stationary objects.

The Anti-Theft Smart Flooring System with Dual Sensor Logic and IoT is designed to overcome these limitations by introducing a novel approach to intrusion detection using the floor as the primary sensing medium. Since every human intruder must physically walk on the floor, this system detects unauthorized presence at the earliest possible stage. The system employs Force Sensitive Resistors (FSR) embedded beneath the flooring to sense pressure and Infrared (IR) sensors to detect movement. A dual-sensor logic is implemented, where human presence is confirmed only when both pressure and motion are detected simultaneously, thereby significantly reducing false triggering.

An ESP32 microcontroller acts as the central processing unit, continuously monitoring sensor data and executing real-time decision-making algorithms. The system divides the floor into multiple zones, enabling zone-wise intrusion detection and display. A buzzer provides immediate audible alerts, while LCD displays show real-time system status and active zones. To enhance security further, a fingerprint-based door locking system is integrated using a fingerprint sensor and servo motor, ensuring that only authorized users can access the protected area.

The project also incorporates IoT functionality using the Blynk platform, allowing remote monitoring, real-time notifications, and mobile-based visualization of zone status. Whenever human presence is detected, instant alerts are sent to the user's smartphone, making the system suitable for modern smart security applications.

Overall, this project presents a low-cost, reliable, scalable, and intelligent security solution that combines sensor fusion, biometric authentication, and IoT technology. It is well-suited for applications such as homes, offices, banks, museums, and restricted zones, and provides an excellent learning platform for students to understand embedded systems, sensor interfacing, signal conditioning, and IoT-based security systems.

I. INTRODUCTION

Security is an essential requirement in modern homes, offices, banks, and other restricted areas due to increasing theft and unauthorized access. Traditional systems like CCTV cameras, motion detectors, and alarms mainly monitor entry points and often fail to provide continuous indoor monitoring. They can also produce false alarms due to pets or environmental factors.To overcome these issues, the Anti-Theft Smart Flooring System uses the floor as a sensing surface. Force Sensitive Resistors (FSRs) detect pressure from footsteps, while Infrared (IR) sensors detect motion. The system uses dual-sensor logic, confirming human presence only when both sensors are triggered, reducing false alarms.AnESP32 microcontroller processes sensor data and controls outputs like alarms and displays. A fingerprint-based door lock system ensures only authorized access using a servo motor. The system also includes an LCD for status display and a buzzer for alerts.With IoT integration using the Blynkplatform, users can monitor the system remotely and receive real-time notifications on their smartphones.Overall, this system provides a smart, accurate, and reliable security solution by combining sensors, biometric authentication, and remote monitoring.

II. LITERATURE SURVEY

In recent years, various approaches have been proposed for improving security systems using sensors, microcontrollers, and IoT technologies for accurate human detection and monitoring:

Smart Home Security System Using ESP32 and IoT:

This study presents an IoT-based smart home security system using the ESP32 microcontroller, which integrates multiple sensors and enables real-time monitoring through mobile applications. The system provides automated alerts and remote access control, improving overall home security and user convenience.

Pressure-Sensitive Floors for Intrusion Detection:
This research highlights the use of pressure-sensitive flooring systems to detect intruders based on applied force. These systems can identify human footsteps by measuring pressure variations, but they may suffer from false alarms due to non-human objects or environmental disturbances.
Infrared Sensor-Based Motion Detection Systems:
This work explains the use of infrared (IR) sensors for detecting motion in security systems. IR sensors are widely used due to their fast response and reliability in detecting human movement, but they may sometimes produce false detections when used alone.
IoT-Based Anti-Theft Systems Using Microcontrollers:
This study focuses on anti-theft systems that use microcontrollers and IoT platforms for real-time monitoring and alert generation. These systems integrate components such as sensors, buzzers, and mobile notifications to provide effective intrusion detection and immediate response.
Integration of Multiple Sensors for Smart Security Applications:
This research emphasizes the importance of combining multiple sensors in a single system to improve accuracy and reliability. Multi-sensor integration helps reduce false alarms and enhances decision-making by analysing data from different sources simultaneously.

III. SYSTEM OVERVIEW

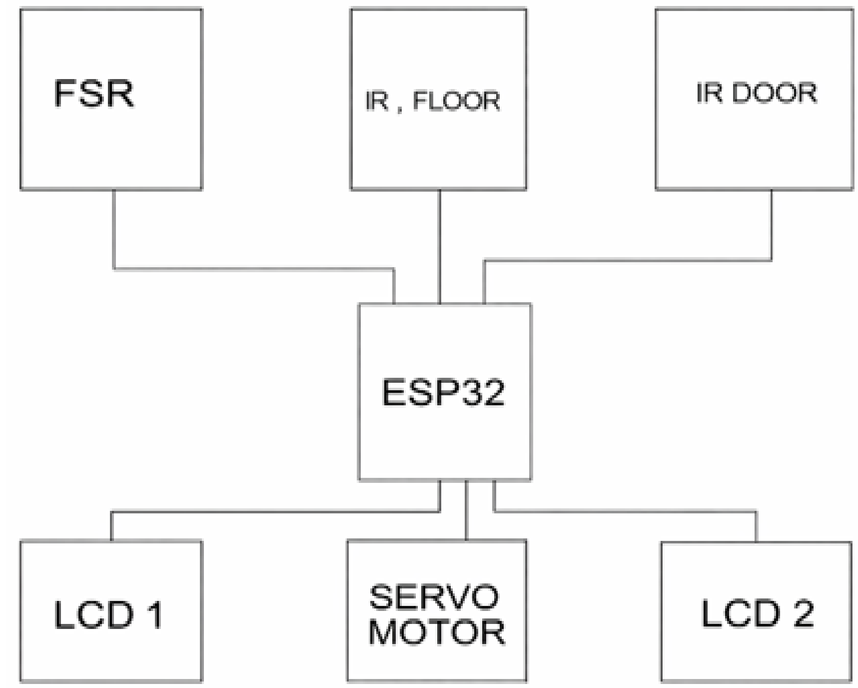

Fig.1 Block Diagram of system

The block diagram shows the working of the Smart Anti-Theft Flooring System with Door Security.

- FSR Sensors are placed under the floor to detect pressure when a person steps on it.
- IR Floor Sensors detect movement of a person on the floor.
- IR Door Sensor checks whether the door is open or closed.
- All sensor signals are given to the ESP32 microcontroller, which acts as the brain of the system.

The ESP32 uses dual logic (FSR + IR) to confirm human presence and avoid false detection.

- LCD 1 displays system and door security information.
- LCD 2 shows floor zone status and human detection messages.
- Servo Motor is used to lock and unlock the door after fingerprint authentication.

The ESP32 also connects to the IoT platform to send alerts and display live status on a mobile app.

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IV. METHODOLOGY

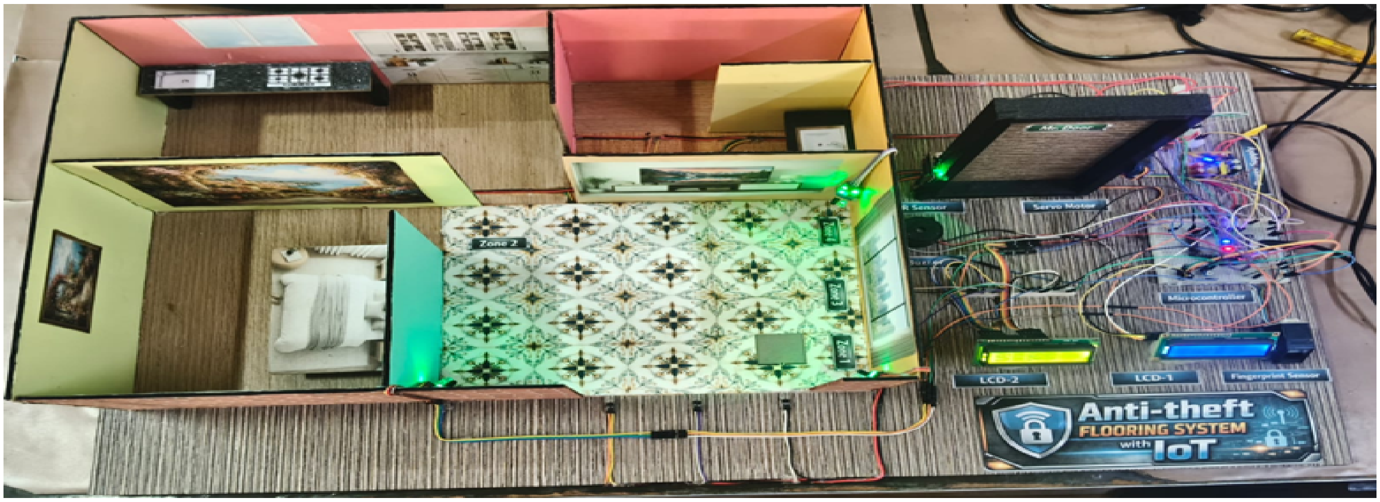

Fig.2 System Photo

Components and their description

1) ESP32 Microcontroller

The ESP32 is the main controlling unit of the project. It receives input signals from FSR sensors, IR sensors, and the fingerprint sensor. Based on the programmed logic, it processes the data, controls the servo motor, updates LCD displays, activates the buzzer, and sends data to the Blynk IoT platform through Wi-Fi. It acts as the brain of the entire system and enables IoT connectivity.

2) FSR (Force Sensitive Resistor) Sensors

FSR sensors are placed beneath the floor surface to detect pressure applied by a human foot. When pressure is applied, the resistance of the FSR decreases, producing a voltage change that is read by the ESP32 using the ADC pins. It is used to detect physical presence on the floor and identify active zones.

3) Floor IR Sensors

Floor IR sensors are used to detect the movement of a person on the floor. These sensors work on the principle of infrared reflection. When a person passes in front of the sensor, the infrared rays transmitted by the IR LED are reflected back and detected by the IR receiver, changing the output signal.

In this project, multiple IR sensors are installed at floor level. The IR sensors alone can detect movement, but they cannot confirm whether the movement is caused by a human or an object. Therefore, their output is combined with FSR sensor data using dual-logic detection.

Importance:

- Confirms movement along with pressure detection
- Reduces false detection caused by objects or shadows
- Improves accuracy of human presence detection

4) IR Door Sensor

The IR door sensor is installed near the door frame to detect door position (open or closed). When the door is opened, the IR beam is interrupted, and the sensor output changes. The ESP32 uses this signal to know when the door is closed again.

This helps the system to automatically lock the door after a person enters, improving safety and automation.

Importance:

- Detects door status in real time
- Helps in automatic locking mechanism
- Prevents accidental open-door conditions

5) Fingerprint Sensor

The fingerprint sensor is a biometric input device used for secure door access. It captures the fingerprint image and compares it with stored fingerprint templates. If a match is found, access is granted; otherwise, it is denied.

In this project, the fingerprint sensor is connected to the ESP32 using UART communication. Authorized fingerprints unlock the door, while unauthorized attempts trigger alerts and notifications through Blynk.

Importance:

- Provides high-level security
- Prevents unauthorized access
- Enhances learning of biometric systems

6) Servo Motor

The servo motor acts as the door locking and unlocking mechanism. It rotates to a predefined angle to lock or unlock the door. When an authorized fingerprint is detected, the servo motor rotates to unlock the door. After the door is closed, it returns to the locked position.

Servo motors are preferred because they provide precise angular control and are easy to interface with microcontrollers.

Importance:

- Enables automatic door control
- Provides precise and reliable movement
- Simple to control using PWM signals

7) LCD Display 1 (I2C LCD)

The first LCD display is connected using the I2C protocol, which reduces wiring complexity. This LCD shows important system messages such as:

- Wi-Fi connection status
- Fingerprint authentication result
- Door open/closed status

This display helps the user understand the system's current state.

Importance:

- Reduces wiring using I2C
- Displays system-level information
- Improves user interaction

8) LCD Display 2 (Parallel LCD)

The second LCD is a parallel 16×2 LCD used specifically for the flooring system. It displays:

- Zone scanning process
- Active and inactive zones
- Human detection messages

This LCD helps in visualizing how the floor detection system works in real time.

Importance:

- Clearly shows zone-wise detection
- Helps during demo and explanation
- Useful for troubleshooting

9) Buzzer

The buzzer is used as an audio alert device. When human presence is detected on the floor or when unauthorized access occurs, the buzzer produces sound alerts. Different beep patterns are used for different events.

In the flooring system, the buzzer alerts continuously or intermittently when a person moves across zones.

Importance:

- Provides instant audio warning
- Enhances security response

- Useful in noisy or dark environments

10) Power Supply

In this project, a 5V power supply is given only to the servo motor, while the other components operate on 5 V from the ESP32. This decision is taken due to the power and current requirements of the servo motor.

The servo motor requires higher current to operate, especially while starting, rotating, or holding its position. The ESP32's internal supply is designed mainly for low-power devices like sensors and cannot safely provide enough current to drive a servo motor.

If the servo motor is powered from the ESP32:

- The ESP32 may reset or hang
- Voltage may drop during servo movement
- System becomes unstable

Therefore, an external regulated 5V supply is provided to the servo motor to ensure smooth and reliable operation.

V. WORKING PRINCIPLE

The Smart Anti-Theft Flooring System works on the principle of detecting human presence using pressure and motion sensing, followed by intelligent decision-making using a microcontroller. The system combines FSR sensors, IR sensors, ESP32 microcontroller, fingerprint-based door access, LCD displays, buzzer, and IoT monitoring to provide a reliable and secure flooring-based security solution.

In this system, the floor itself becomes a sensing medium, capable of detecting whether a real human is present or not.

When a person walks on the floor, pressure is applied on the floor surface and movement occurs simultaneously. The FSR sensors installed beneath the floor detect the pressure, while IR sensors detect movement. These sensor signals are processed by the ESP32 microcontroller, which confirms human presence only when both pressure and motion are detected together. This dual logic avoids false detection caused by objects, shadows, or vibrations.

FSR (Force Sensitive Resistor) sensors are used to sense pressure applied on the floor. The resistance of an FSR is very high when no pressure is applied and decreases as pressure increases. However, the ESP32 cannot measure resistance directly. It can only read voltage through its ADC pins.

To solve this, the FSR is connected in a voltage divider circuit with a fixed 10kΩ resistor and a 5V supply. When pressure is applied on the FSR, its resistance decreases, which increases the voltage at the divider output. This output voltage is then fed to the ADC pin of the ESP32.

The voltage divider works according to the formula:

Vout= Vin □ R2(Fixed)

(R1(FSR)+R2(Fixed)

Where in, Rfixed = 10kOhm

R FSR varies with pressure, Vin =5V

When no pressure is applied on the floor, the FSR resistance is very high (around 1MΩ). In this condition, the output voltage becomes very small, approximately 0.05V, which results in a very low ADC value. The ESP32 treats this as zone inactive.

When light pressure is applied (for example, placing an object), the resistance reduces to around 50kΩ. This increases the output voltage to approximately 0.83V, but it is still below the threshold set for human detection. Hence, false triggers are avoided.

When a human steps on the floor, the pressure causes the FSR resistance to drop significantly (around 5kΩ). In this case, the output voltage rises close to 3.3V, which corresponds to a high ADC value (near 4095). The ESP32 detects this as FSR active.

Thus, the voltage divider plays a critical role in converting physical pressure into a usable electrical signal.

Along with pressure detection, IR sensors are placed on the floor to detect movement. When a human passes in front of an IR sensor, its output changes state. The ESP32 continuously monitors all IR sensors, and if any one IR sensor detects movement, it considers motion to be present.

This ensures that pressure caused by heavy objects without movement is not falsely treated as human presence.

Dual Logic for Human Detection

The core logic of the system is based on dual sensor confirmation:

Human Presence = Pressure Detected (FSR) AND Motion Detected (IR)

If:

- IR sensor is active but no FSR is active → No human detected
- FSR is active but IR is inactive → No human detected
- Both FSR and IR are active → Human detected

This logic significantly improves accuracy and reliability.

As long as a person remains on the floor and moves across zones, the system keeps detecting pressure and motion, updating zone information dynamically. This makes the flooring system suitable for real-world applications such as restricted areas, labs, vaults and secure corridors.

VI. RESULT AND DISCUSSION

The system has been successfully tested under various real-time conditions where pressure and motion parameters were varied to simulate human presence and environmental disturbances. The system provided immediate feedback through visual, audible, and IoT-based alerts, demonstrating its effectiveness in real-time human detection and security monitoring.Human Detection and Sensor Performance: The system correctly identified human presence only when both FSR (pressure) and IR (motion) sensors were activated simultaneously, effectively eliminating false detections caused by objects, vibrations, or environmental factors. The FSR sensors accurately differentiated pressure levels, while the IR sensors ensured instant motion detection.Zone Monitoring and Alert System: The system successfully monitored different zones and displayed real-time updates on the LCD and IoT platform. Alerts were triggered instantly through buzzer, LCD display, and mobile notifications for any detected intrusion or unauthorized access.These results confirm that the proposed system is capable of effectively detecting human presence, minimizing false alarms, and providing timely alerts for enhanced security monitoring.

VII. CONCLUSION

The Smart Anti-Theft Flooring System provides a reliable and efficient solution for enhancing security through real-time human detection. The integration of FSR (pressure) and IR (motion) sensors enables accurate identification of human presence using dual logic, significantly reducing false alarms caused by non-human factors.

The use of the ESP32 microcontroller allows fast processing and seamless integration with IoT platforms for real-time monitoring and alerts. Additionally, the inclusion of fingerprint-based access control ensures that only authorized users can enter restricted areas, thereby strengthening overall security.

This automated system improves surveillance efficiency, provides immediate alerts through visual, audible, and mobile notifications, and ensures continuous monitoring of secured zones. Hence, the proposed system enhances safety, reliability, and effectiveness in modern security applications such as laboratories, vaults, and restricted access areas.

VIII. ACKNOWLEDGMENT

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