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IoT-based inmate tracking and escape alert system

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ABSTRACT :

The **IoT-Based Inmate Tracking and Escape Alert** System enhances prison security through real-time monitoring using GPS, GSM, DHT11 sensors, piezoelectric sensors, and Arduino Uno. GPS ensures precise location tracking, while GSM sends instant alerts to security personnel. DHT11 sensors maintain a safe environment by monitoring temperature and humidity, and piezoelectric sensors detect unauthorized movements or escape attempts. Arduino Uno processes all data, ensuring seamless operation. By minimizing the need for constant manual supervision, this system enhances security, improves response times, and streamlines prison management, marking a significant advancement in the use of IoT for intelligent corrections.

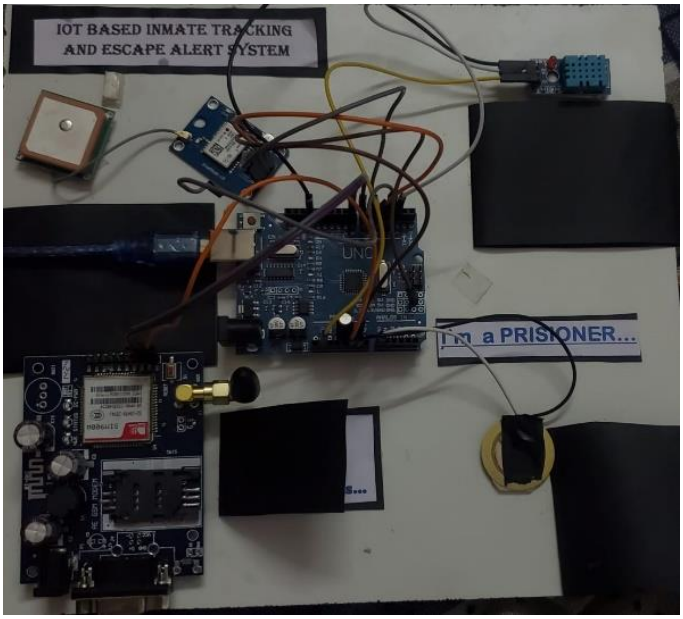
I. INTRODUCTION :

Ensuring security within the correctional facility is highly challenging because constant surveillance over inmates requires a lot of workforce and infrastructure. Conventional methods, including manual supervision and security cameras, are often cumbersome, prone to human error, and lacking in protection against attempts at escaping or engaging in unauthorized activities. The Internet of Things technology is, therefore an effective method for automated, accurate, and reliable tracking of inmates and facility security.

The IoT-based system, Inmate Tracking and Escape Alert System designed using GPS, GSM, DHT11 sensors, piezoelectric sensors, and Arduino Uno provides real-time location tracking in collaboration with environmental monitoring facilities and instant alert notification facilities for improved efficiency in prison management. This is because it tracks the location of inmates with greater accuracy while enabling authorities to monitor their movements within the facility. The GSM module acts as a communication bridge and sends alarm messages to the security personnel every time suspicious movement occurs. DHT11 is also a temperature and humidity sensor, which prevents extreme environmental conditions from occurring inside that could endanger inmate health. Piezoelectric sensors monitor vibration, an indicator of movement that could imply the inmate was escaping or breaking open security barriers. Arduino Uno is a system central processor where all sensors feed data in order to smoothly work.

By integrating these IoT-based technologies, the system gives an effective solution for automated surveillance, early escape detection, and improved response time. It has the capability of sending real-time alerts to the security personnel to act on them immediately, which minimizes the risk of inmates escaping and doing unauthorized activities. In addition, the system reduces reliance on manual supervision, as human resources can be utilized more critically in other security operations.

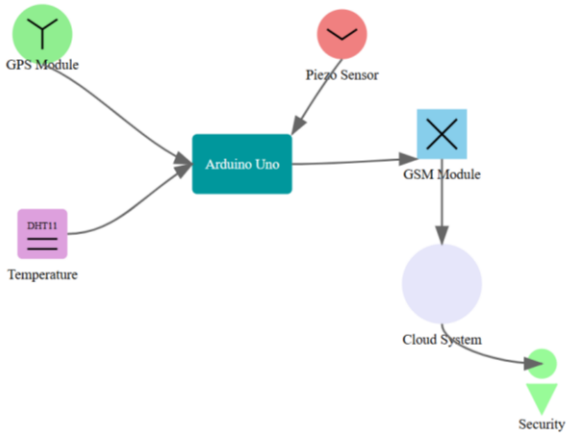
With the rapid adoption of IoT in law enforcement and facility management, this system is a significant technological advancement in prison security. It enhances tracking capabilities, improves environmental monitoring, and automates alerts, providing a proactive approach to inmate supervision, thereby strengthening overall prison security and ensuring public safety.



II. OBJECTIVES :

The IoT-Based Inmate Tracking and Escape Alert System is developed to make correctional facilities more secured and managed with better implementation of Internet of Things technology. This system tracks inmates automatically, detects unauthorized movements, and gives security personnel real-time alerts about the inmates in their custody while allowing a safer prison environment. The primary objectives of the system are:

1. **Real-Time Inmate Tracking-** Integrate the facility with GPS technology that monitors inmates at every minute of time in terms of the location, thereby accurately recording movement. The chance of breakouts or accessing prohibited areas without authority is therefore significantly reduced.
2. **Automated Security Alerts -** Use GSM modules to alert prison officials immediately whenever an anomaly occurs, an inmate tries to escape, or there is any security breach. This will contribute to faster response times and thus better security.
3. **Environmental Monitoring for Inmate Safety –** Integrate DHT11 sensors to monitor temperature and humidity levels within prison cells and communal areas. This ensures that the environment remains safe and suitable for inmates, reducing health risks due to extreme conditions.
4. **Unauthorized Movement and Escape Detection -** Install piezoelectric sensors that can pick up vibrations due to unauthorized movements, tampering on walls, or attempting to breach security barriers. This enables authorities to take necessary precautions much earlier when the activities first occur, preventing a successful full-scale escape attempt.
5. **Efficient Data Processing and System Integration –** Arduino Uno will be the central processing unit for collecting, analyzing, and managing sensor data. The system will ensure effective communication between different components to achieve real-time monitoring without delay.
6. **Enhanced Response Time for Security Personnel –** The system allows for real-time alerts, which means faster decision-making and response actions, thus reducing the chances of inmates successfully escaping. This automation significantly improves operational efficiency compared to traditional monitoring systems.
7. **Minimize Dependence on Manual Monitoring –** The conventional methods of inmate tracking are heavily dependent on manual monitoring, which is susceptible to human error and inefficiencies. This system reduces the burden on prison staff to focus on other critical aspects of prison management.
8. **Strengthening Correctional Facility Security –**This system strengthens correctional facility security using advanced IoT-based surveillance mechanisms that provide a proactive approach to prison security. Considering the integration of real-time tracking, environmental monitoring, and instant alerts, the facility can more feasibly prevent security breaches.
9. **Data Logging and Analysis for Future Planning –** The system tracks data on the inmate movement, the environmental conditions, and security alerts. This information can help to analyze data over time, find patterns, strengthen the security strategies, and improve overall management in prisons.
10. **Scalability and future expansion-** The system is quite scalable. Therefore, based on the requirements and needs of time, more sensors or features can be incorporated later for further enhancement in security measures. It can easily be adapted for other high-security environments like detention centers and rehabilitation facilities.



III. PROBLEM STATEMENT :

Current prison monitoring systems are mostly dependent on manual surveillance, routine inspections, and security cameras, all of which need constant human supervision. Traditional methods are time-consuming, labor-intensive, and prone to human error, thus being inefficient in dealing with security threats. Prison staff have to monitor multiple inmates and areas at the same time, leading to fatigue, oversight, and delayed responses to security breaches. One of the significant disadvantages of manual monitoring is that the reaction to such incidents as jailbreaks, tampering with prison structures, or unauthorized movements is delayed. The large size of prisons and limited staff hinder the real-time detection of an escape attempt. Moreover, prisoners can manipulate walls, locks, or fences without immediate detection, thus increasing security risks. Automated alerts are also absent in traditional systems, which means security breaches are noticed only after they occur.

To address these issues, there is a need for an intelligent IoT-based inmate tracking and security alert system. By integrating GPS for tracking, GSM for alerts, piezoelectric sensors for movement detection, and DHT11 sensors for environmental monitoring, real-time tracking and automated alerts can improve prison security, reduce response time, and alleviate operational challenges.

IV. PROPOSED SYSYTEM :

The IoT-Based Inmate Tracking and Escape Alert System integrates several smart components to increase security, surveillance, and real-time monitoring within correctional facilities. Using the IoT technology, the system automatically tracks inmates and sends immediate alerts in case of security breaches or environmental hazards. The system improves prison security and operational efficiency to a great extent. The system architecture consists of several interconnected components that work in unison to detect, analyze, and respond to potential escape attempts, unauthorized movements, or environmental hazards.

1. GPS Module – Inmate Location Tracking in Real Time

The module of the Global Positioning System (GPS) is very significant in tracking inmate locations within the prison facility. This module allows for real-time positioning data to be provided so that security personnel can monitor their movements accurately and detect unauthorized access to restricted

areas or escape attempts. The system ensures that every inmate is accounted for by continuously transmitting location coordinates, reducing the risk of undetected movements or disappearances.

- It facilitates continuous monitoring of the location of the inmates.
- Provides alert towards suspicious movement meant to proclaim escape.
- Integrates with the GSM module for communicating positional updates.

2. GSM Module – Wireless Data Transmission & Security Alerts

The GSM module provides real-time communication between the system and the security personnel, transmits wirelessly the location data and sensor to the central monitoring station. All the details will be directly flashed to the concerned security personnel immediately.

- This sends alerts and notification to authorities whenever abnormal behavior happens or whenever attempts are being done to try escaping.
- Makes the communication channel to the security staff and monitoring system not broken anytime.
- It allows remote surveillance, so manual observation of them is reduced day by day

3. Piezoelectric Sensors- Movement and tamper detection

These piezoelectric sensors gauge mechanical stress along with pressure to detect the minute vibrations or slight movements within structures. The above sensors will become very helpful and efficient to ensure that illegal entry or any escape attempt of criminal prisoners takes place. This has to be incorporated near the door, fences or walls or along with sensitive boundaries.

- Detects vibrations from drilling, cutting, or breaking through walls or barriers.
- Detects mechanical stress applied to security structures.
- Works in conjunction with the GSM module to send alerts when tampering is detected.

4. DHT11 Sensors – Environmental Monitoring for Inmate Well-Being

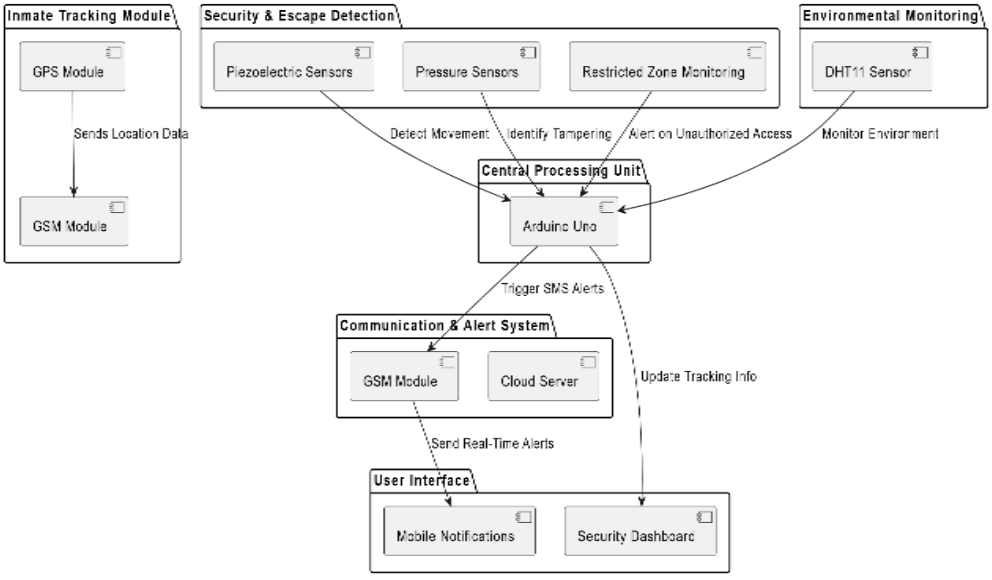
The sensor DHT11 should check temperature and humidity levels within the correctional facility. Inmates' health would be maintained and welfare in general because extreme conditions in the environment provoke risks to health, discomfort, or unrest among inmates.

- Continuously checks temperature and humidity inside the prison.
- Ensures environment conditions within secured limits.
- Facilitates prison authorities from extreme weather conditions affecting well-being of inmates within the prison.

5. Arduino Uno Core Processing and Control System

The Arduino Uno will be the main processing unit, combining data from GPS, GSM, piezoelectric, and DHT11 sensors, which will process signals, recognize anomalies, and send security signals. In cases of suspicious activities or abnormal conditions, it immediately sends alerts to the monitoring center via GSM.Real-time collection and processing of sensor data.

- Detections of abnormally conducted movement, environmental change, or escape attempts.
- Send command to the GSM module to give information about threats.
- Implementation of predefined security protocols according to sensor inputs.



V. HARDWARE AND SOFTWARE REQUIREMENTS :

HARDWARE REQUIREMENTS:

- Arduino Uno
- GPS Module
- GSM Module

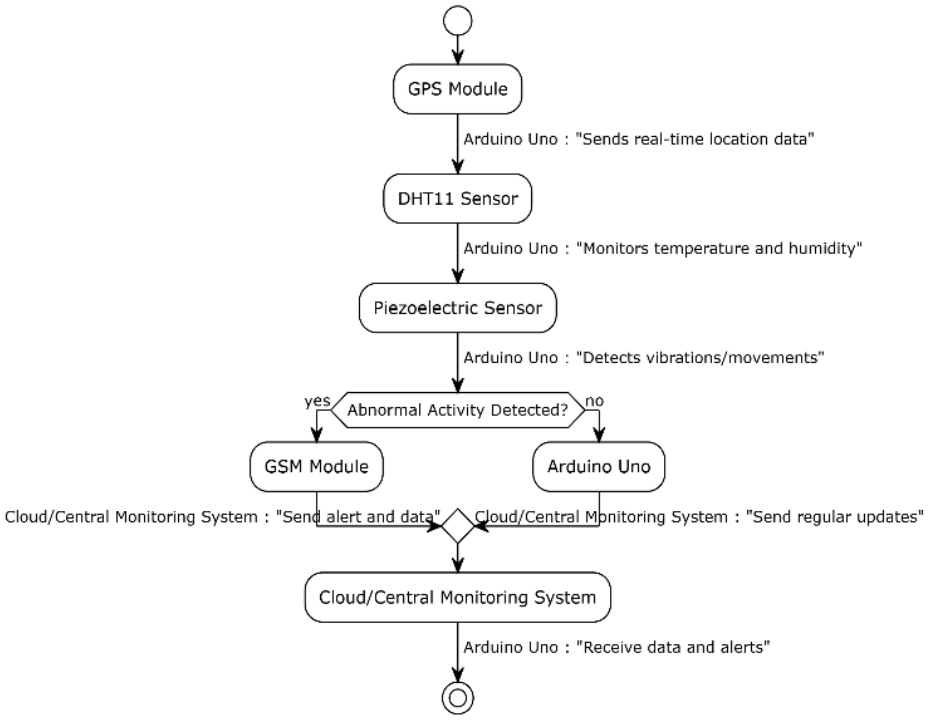
- Piezoelectric Sensors
- DHT11 Sensors

SOFTWARE REQUIREMENTS:

- Arduino IDE
- Embedded C/C++
- Cloud-based monitoring dashboard
- SQL database for data storage

VI. System Implementation :

1. **Data Collection:** Various sensors, including GPS for location tracking, pressure and piezoelectric sensors for detecting unauthorized movement, and DHT11 for temperature and humidity monitoring, continuously gather real-time data. This ensures comprehensive surveillance of inmate activities and environmental conditions within the facility.
2. **Data Transmission:** The collected data is transmitted to a central monitoring system using a GSM module. This enables real-time communication between the tracking system and security personnel, ensuring that any critical updates regarding inmate movement or environmental changes are relayed without delay.
3. **Analysis & Alerts:** The Arduino microcontroller processes incoming data and analyzes it for anomalies. If abnormal activities such as unauthorized movement, excessive humidity, or an attempted escape are detected, the system automatically triggers alerts. These alerts can activate alarms, notify security staff, or initiate automated security protocols to mitigate risks.
4. **User Interface:** Security personnel can monitor inmate activities and environmental conditions through a cloud-based dashboard. The interface provides live updates, historical data analysis, and visual representations of movement patterns, allowing for informed decision-making and improved response times in case of security breaches.



VII. Testing and Evaluation :

1. Unit Testing (Testing Individual Components)

Each hardware and software component is tested separately to confirm functionality before system integration.

- **GPS Module:** Checks location accuracy, update frequency, and signal stability in different environments.
- **GSM Module:** Tests data transmission reliability and the ability to send alerts without delays.
- **Piezoelectric Sensors:** Verifies sensitivity to unauthorized movements or vibrations.
- **DHT11 Sensor:** Ensures accurate temperature and humidity monitoring.
- **Arduino Uno:** Confirms proper data processing and response to sensor inputs.

2. Integration Testing (Ensuring Smooth Communication)

This phase checks how well different system components work together.

- GPS, GSM, and sensors are integrated and tested for real-time data flow.
- The system is monitored to verify correct alert triggering based on different sensor inputs.
- Compatibility issues between hardware and software are identified and resolved.

3. Performance Testing (Evaluating Speed and Efficiency)

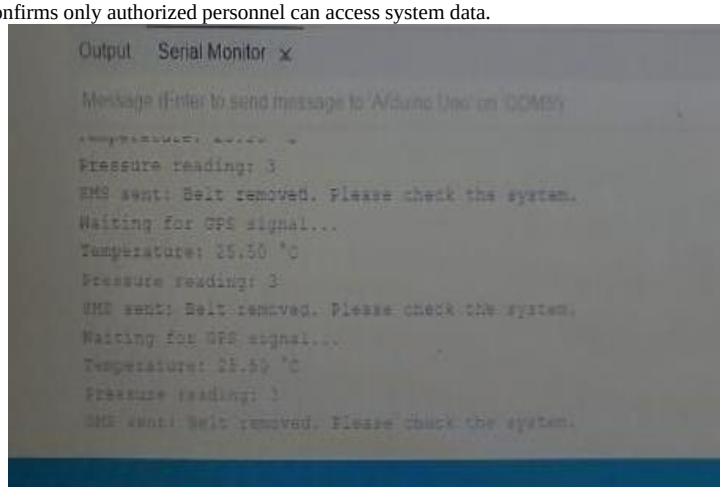
The system is tested under various real-world conditions to measure its effectiveness.

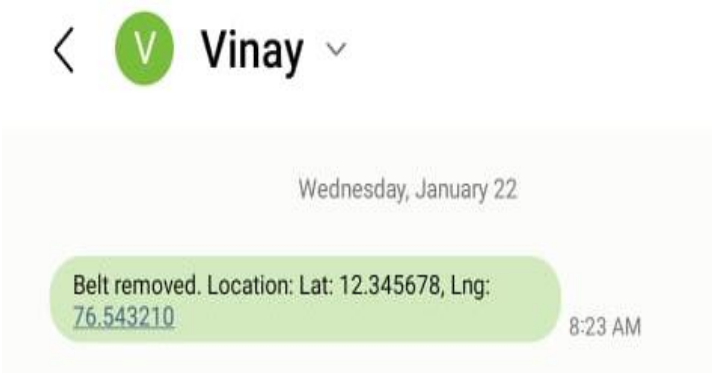
- **Real-time tracking:** Ensures GPS updates inmate locations without significant delays.
- **Alert responsiveness:** Tests how quickly alerts reach security personnel after an unauthorized movement.
- **System stability:** Checks if the system continues functioning properly under high load conditions.

4. Security Testing (Preventing Unauthorized Access)

To ensure system integrity and data protection, security vulnerabilities are tested.

- **Encryption methods:** Verifies secure data transmission between IoT devices and the monitoring system.
- **Tamper detection:** Ensures sensors can detect and report any attempts to disable them.
- **Authentication checks:** Confirms only authorized personnel can access system data.





VIII. Conclusion :

The IoT-Based Inmate Tracking and Escape Alert System presents a transformative solution to security challenges in correctional facilities. By leveraging Internet of Things (IoT) technologies, the system enables real-time tracking, automated alerts, and efficient monitoring of inmates within prison premises. Utilizing advanced sensors, GPS, RFID, and communication networks, the system ensures continuous surveillance, significantly reducing the risk of escapes and unauthorized movements.

The implementation of this technology enhances security management by providing instant notifications to authorities in case of unusual activities, ensuring swift response measures. Additionally, it minimizes manual supervision efforts while improving accuracy and reliability in monitoring inmate locations. By integrating IoT into correctional facility security, this system fosters a safer, more controlled environment, ultimately strengthening prison administration and overall public safety.

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